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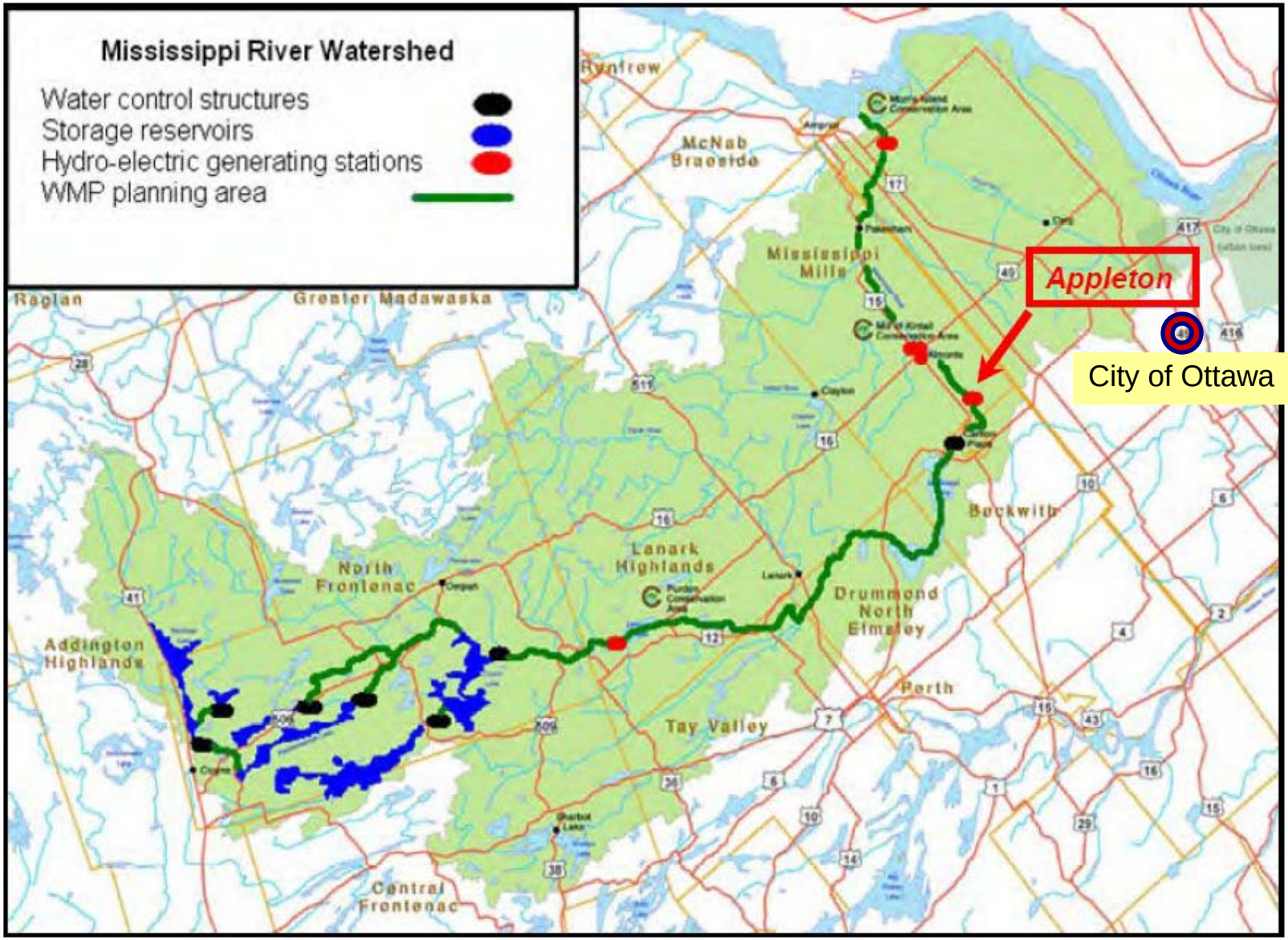
Implications of Climate Change to Stormwater Management

Guelph Watershed Research Group
University of Guelph, Guelph, Ontario, Canada

Paul Lehman and Sobhalatha Kunjikutty
Mississippi Valley Conservation, Lanark, Ontario, Canada

OCCAR Climate Change Adaptation Workshop
Hamilton, March 9, 2011

Study Area


Mississippi River Watershed
Water control structures
Storage reservoirs
Hydro-electric generating stations
WMP planning area
Appleton
City of Ottawa
Renfrew
McNab Braeside
Mississippi Mills
Greater Madawaska
Raglan
North Frontenac
Lanark Highlands
Addington Highlands
Tay Valley
Drummond North Elmsley
Perth
Beckwith
Central Frontenac

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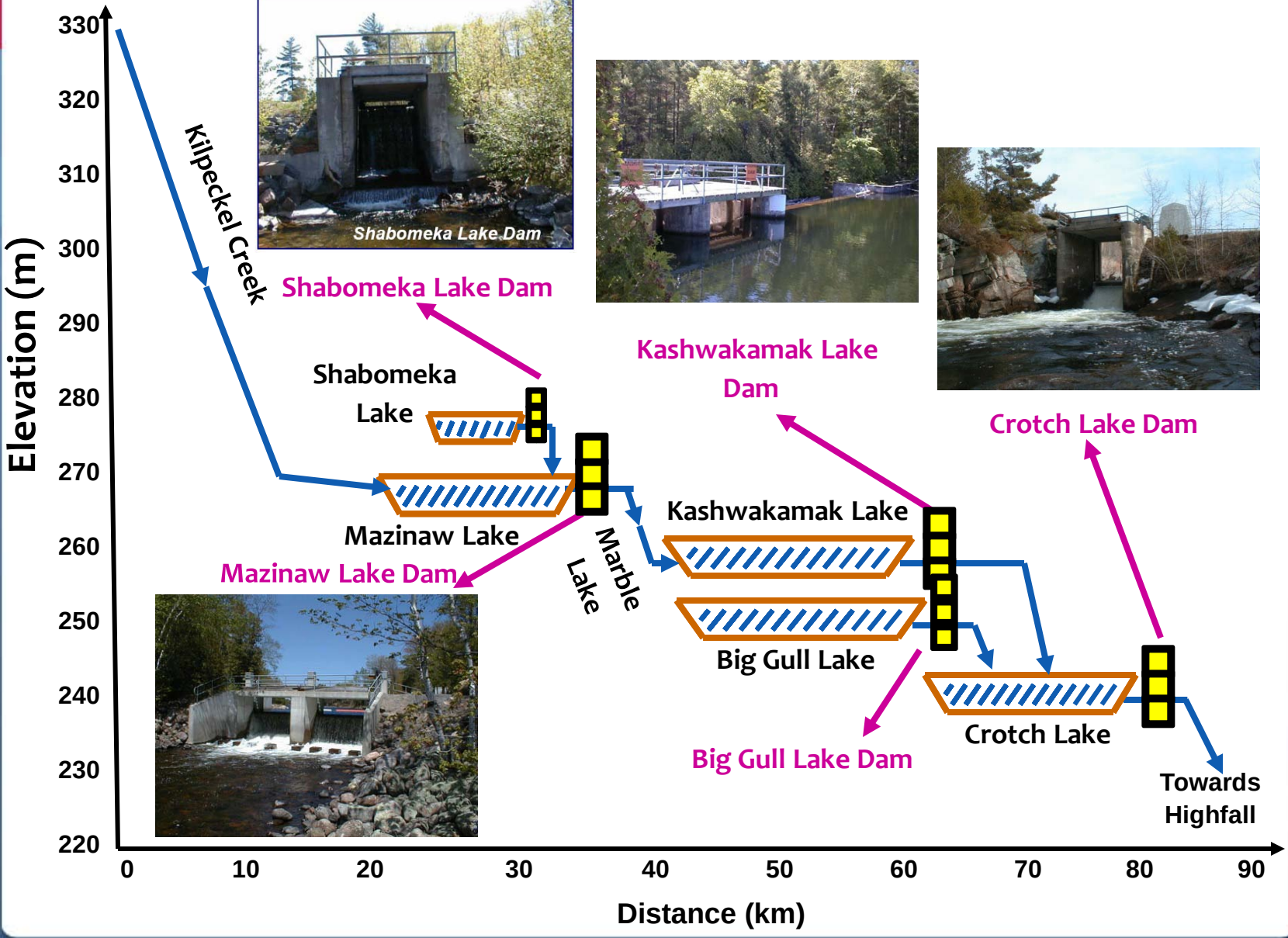
Mississippi River Profile



The 3-Year Cycle !!!

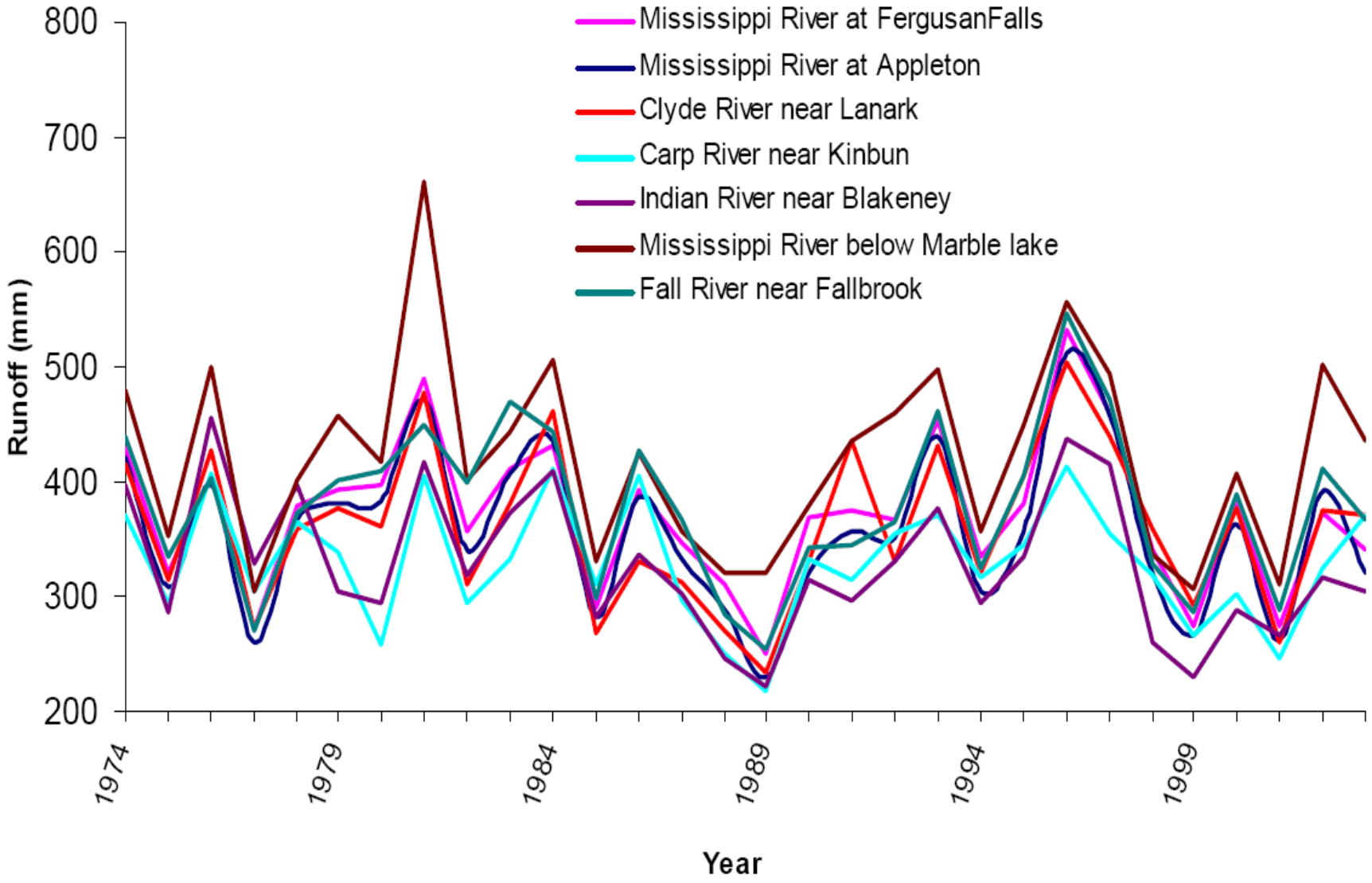
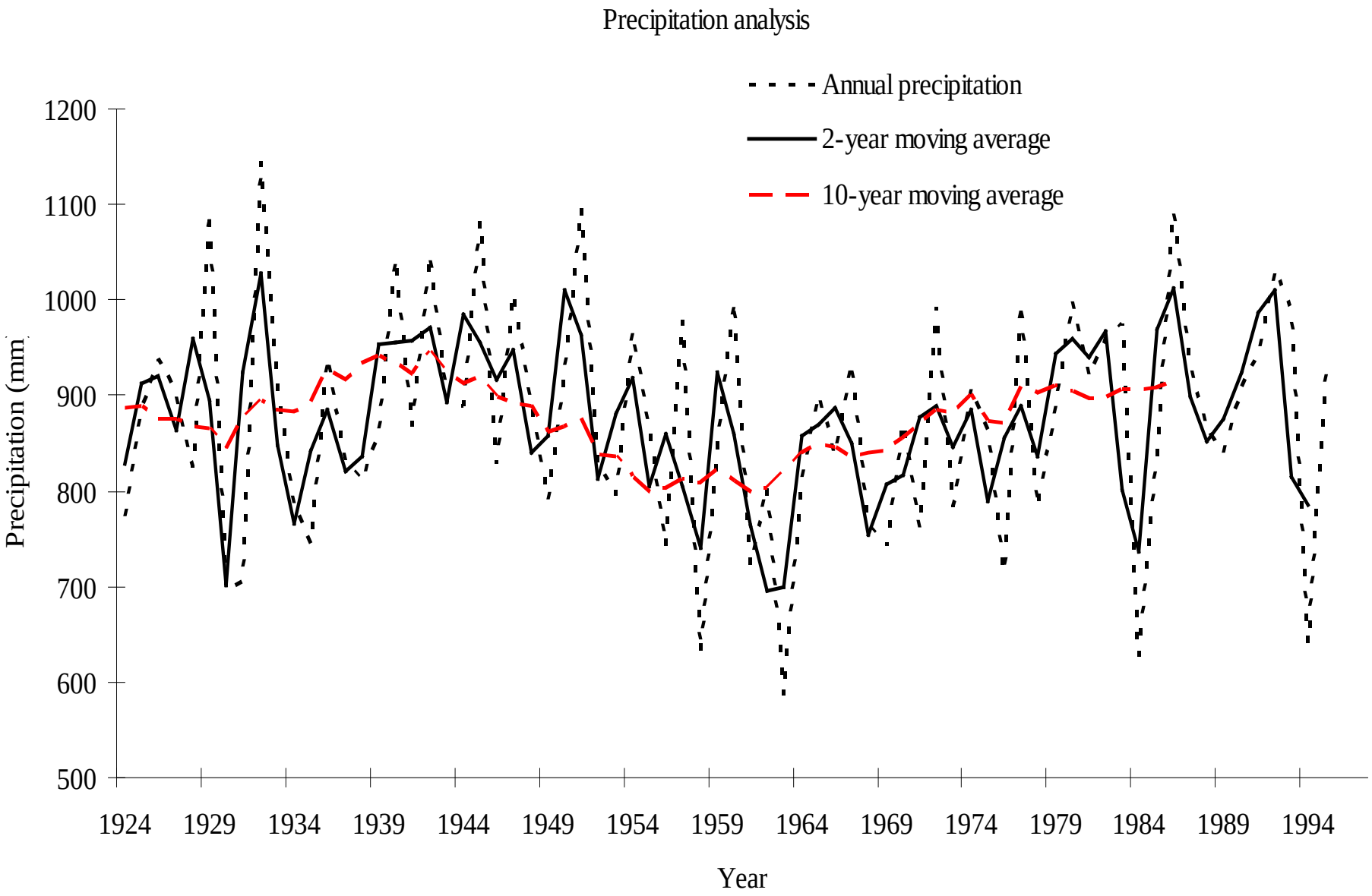
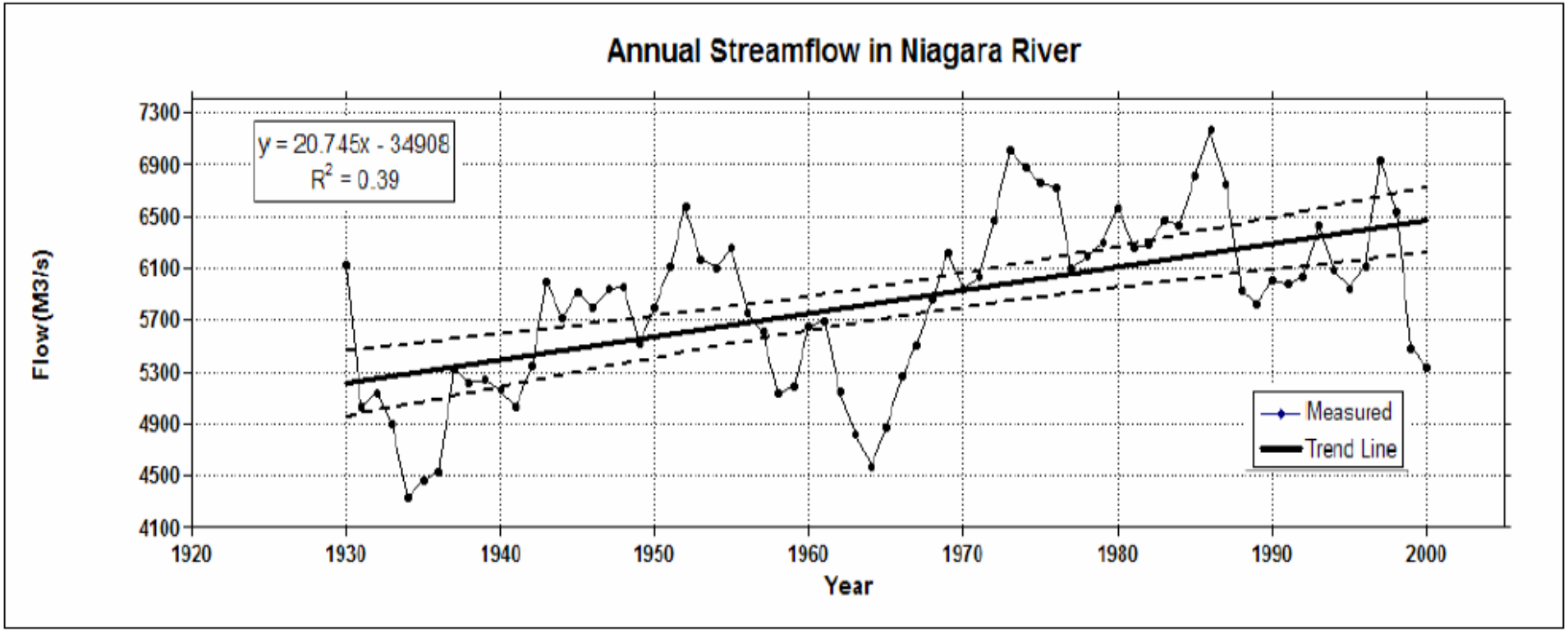
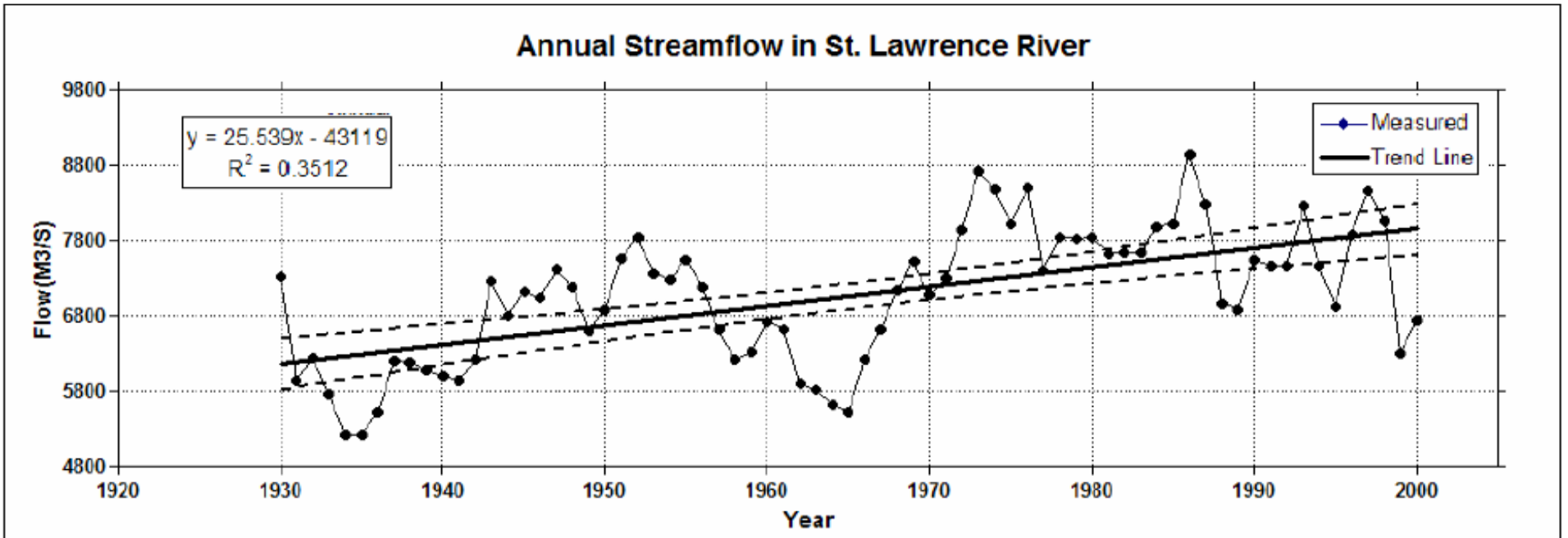


Figure 3-11 Mean annual runoff (mm) – Mississippi Stations (1974-2003)

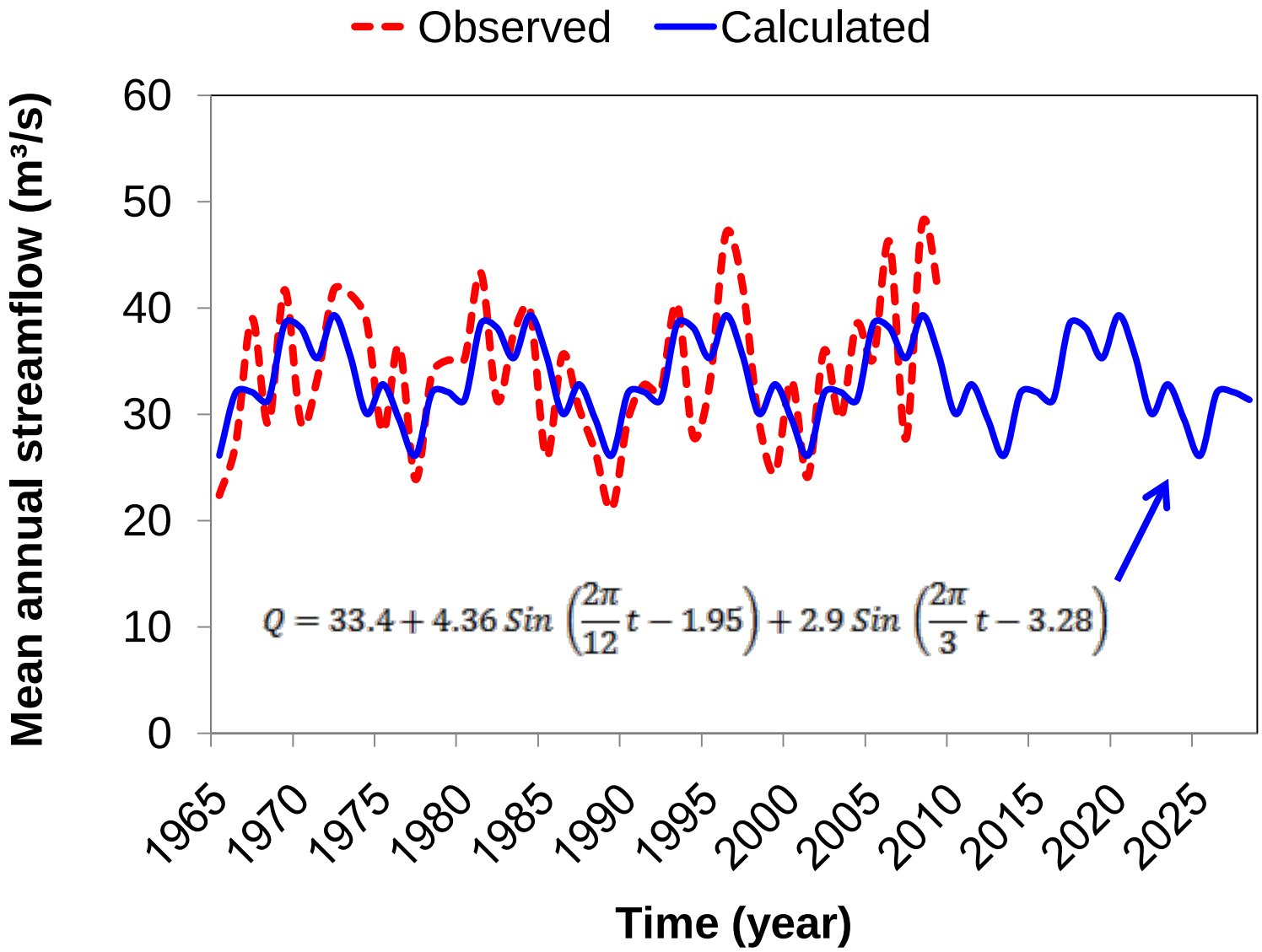
Orono meteorological station (1923 to 1996)



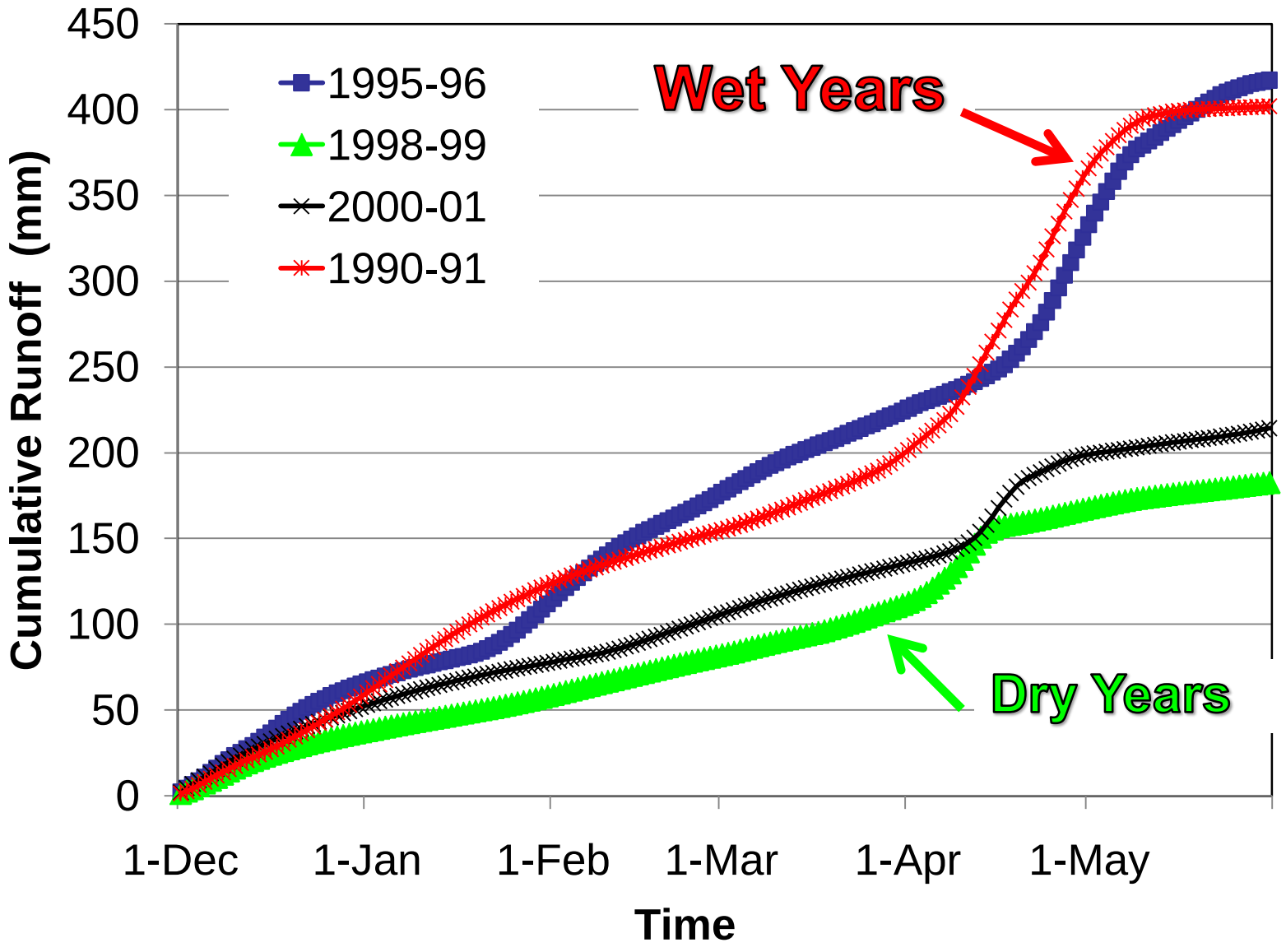

Annual Streamflow in Niagara River
y = 20.745x - 34908
R2 = 0.39
Flow(M3/s)
Year
Measured
Trend Line
7300
6900
6500
6100
5700
5300
4900
4500
4100
1920
1930
1940
1950
1960
1970
1980
1990
2000


Annual Streamflow in St. Lawrence River
y = 25.539x - 43119
R2 = 0.3512
Flow(M3/S)
Year
Measured
Trend Line
9800
8800
7800
6800
5800
4800
1920
1930
1940
1950
1960
1970
1980
1990
2000

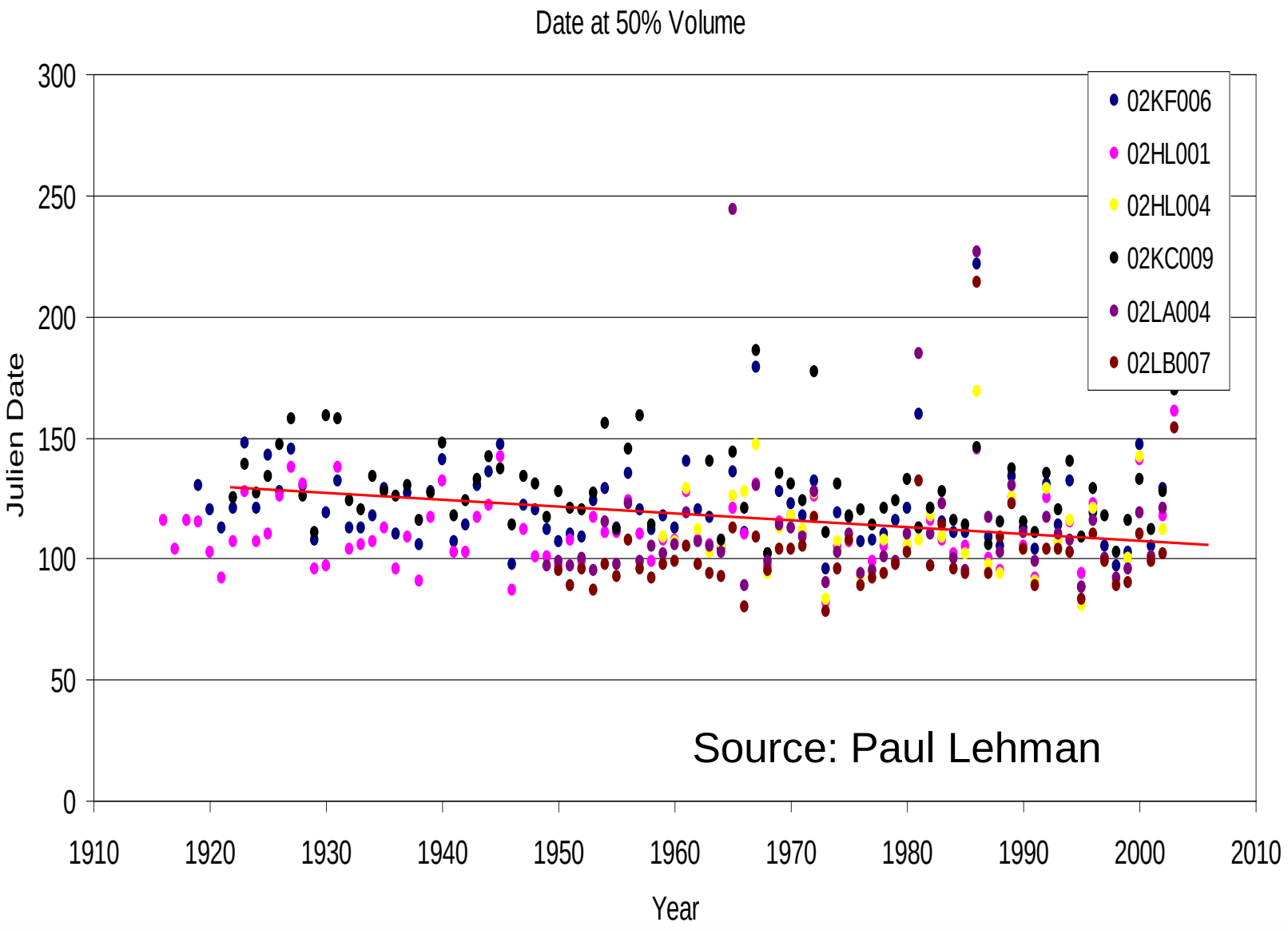
Mississippi River at Appleton (02KF006)



The Spring Snowmelt



Date at 50%Volume



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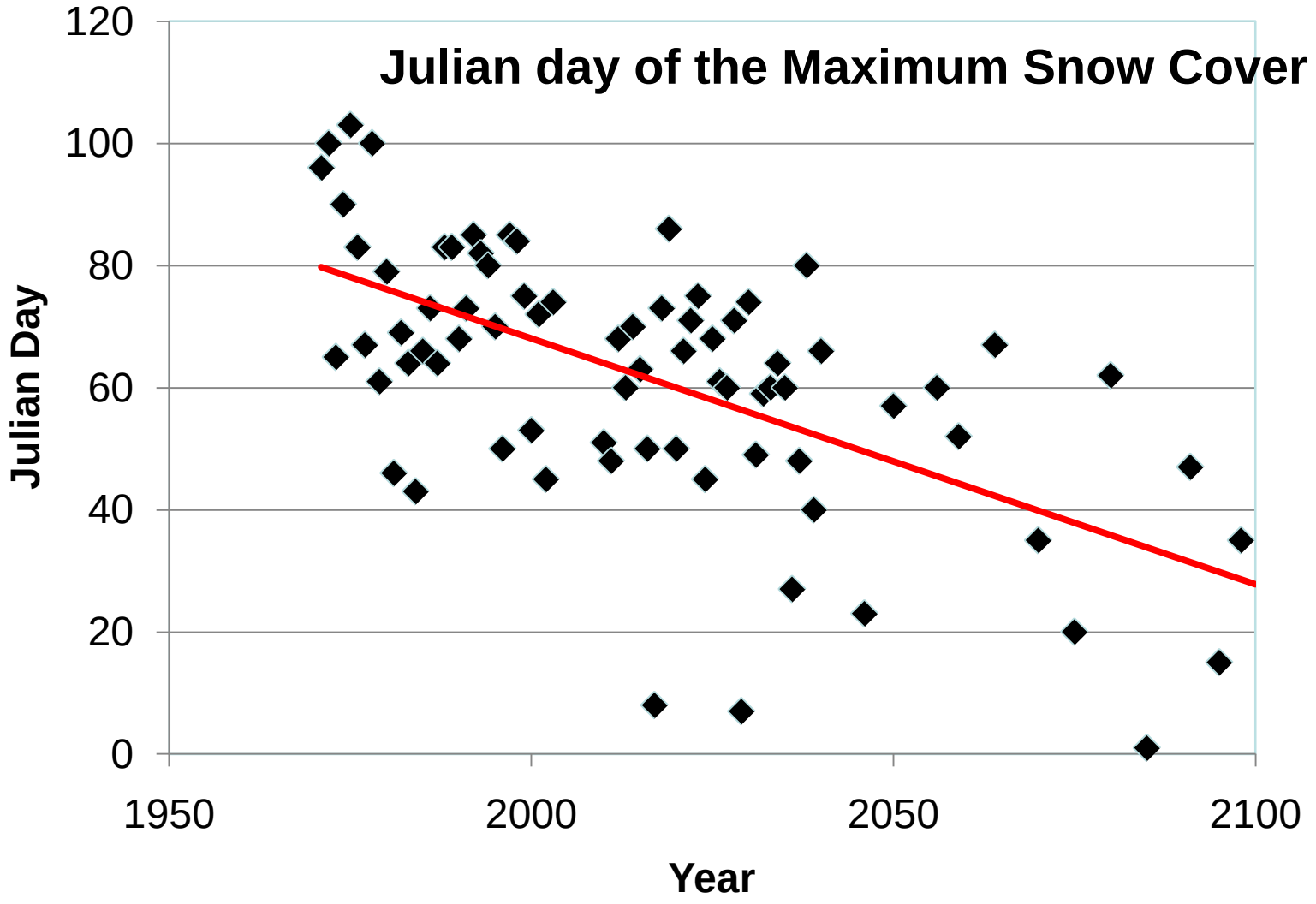
Spring Snowmelt's Timing



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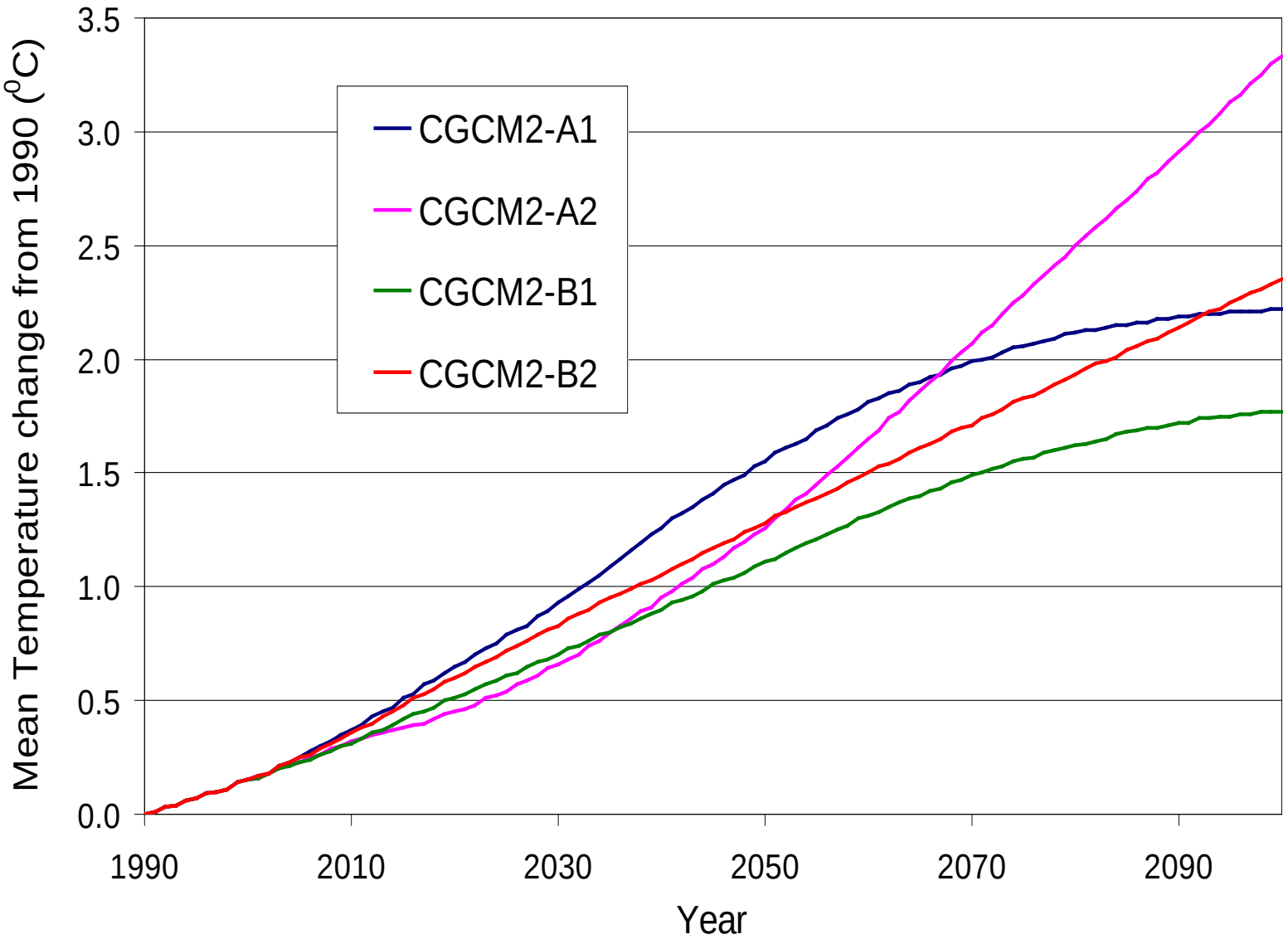
Mean Temperature change from 1990 (^{0}C)



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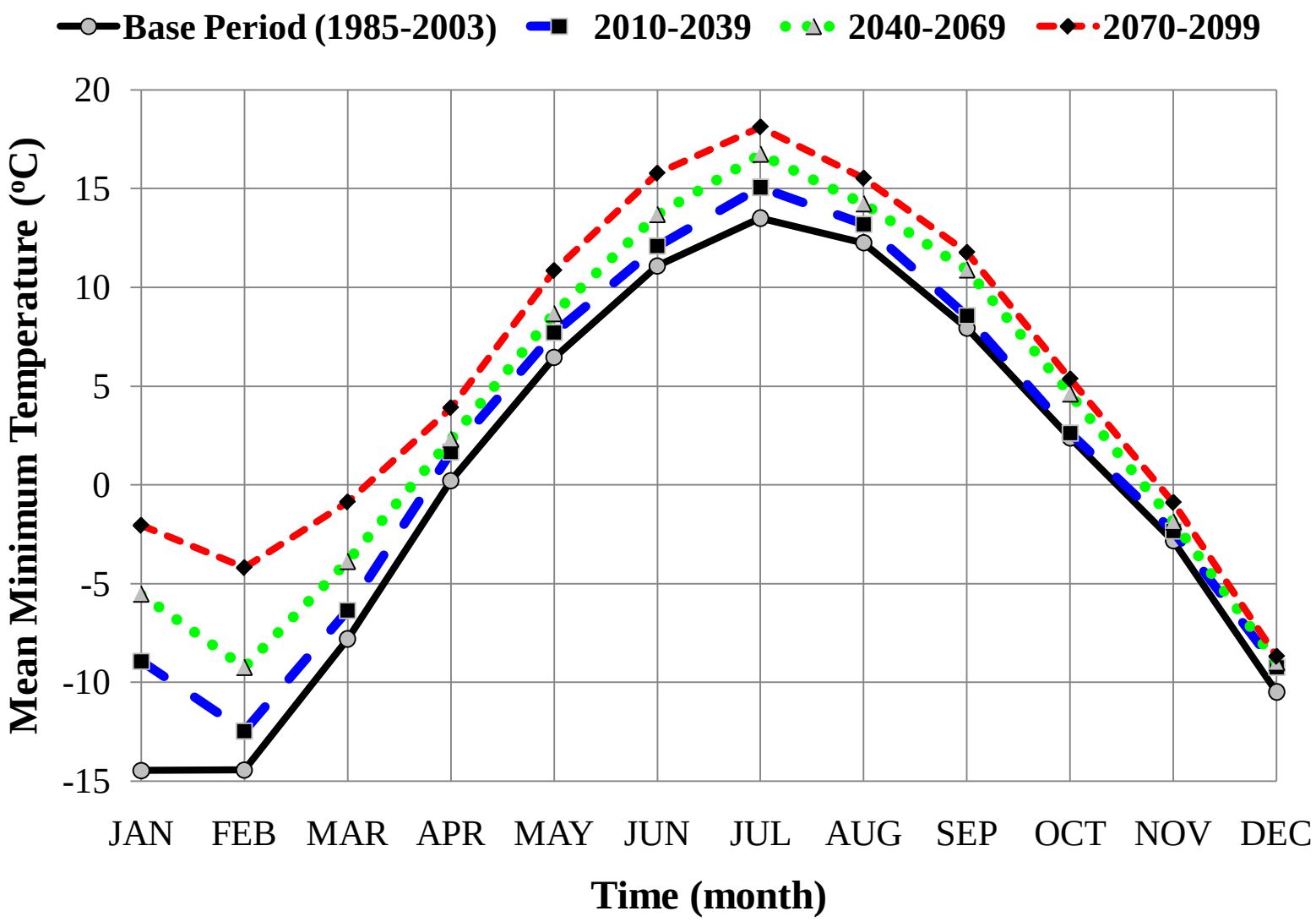
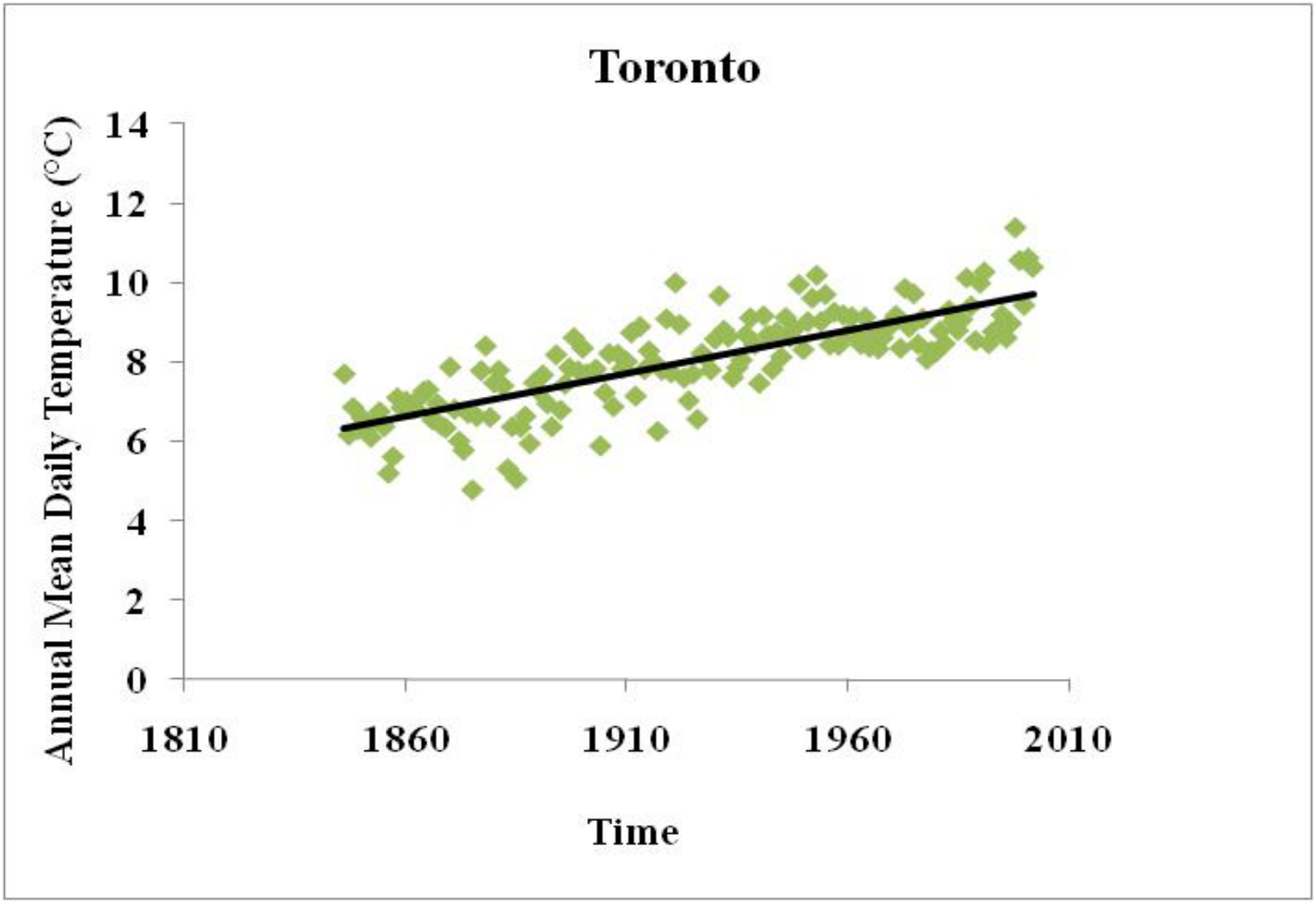
Future Temperature Predictions



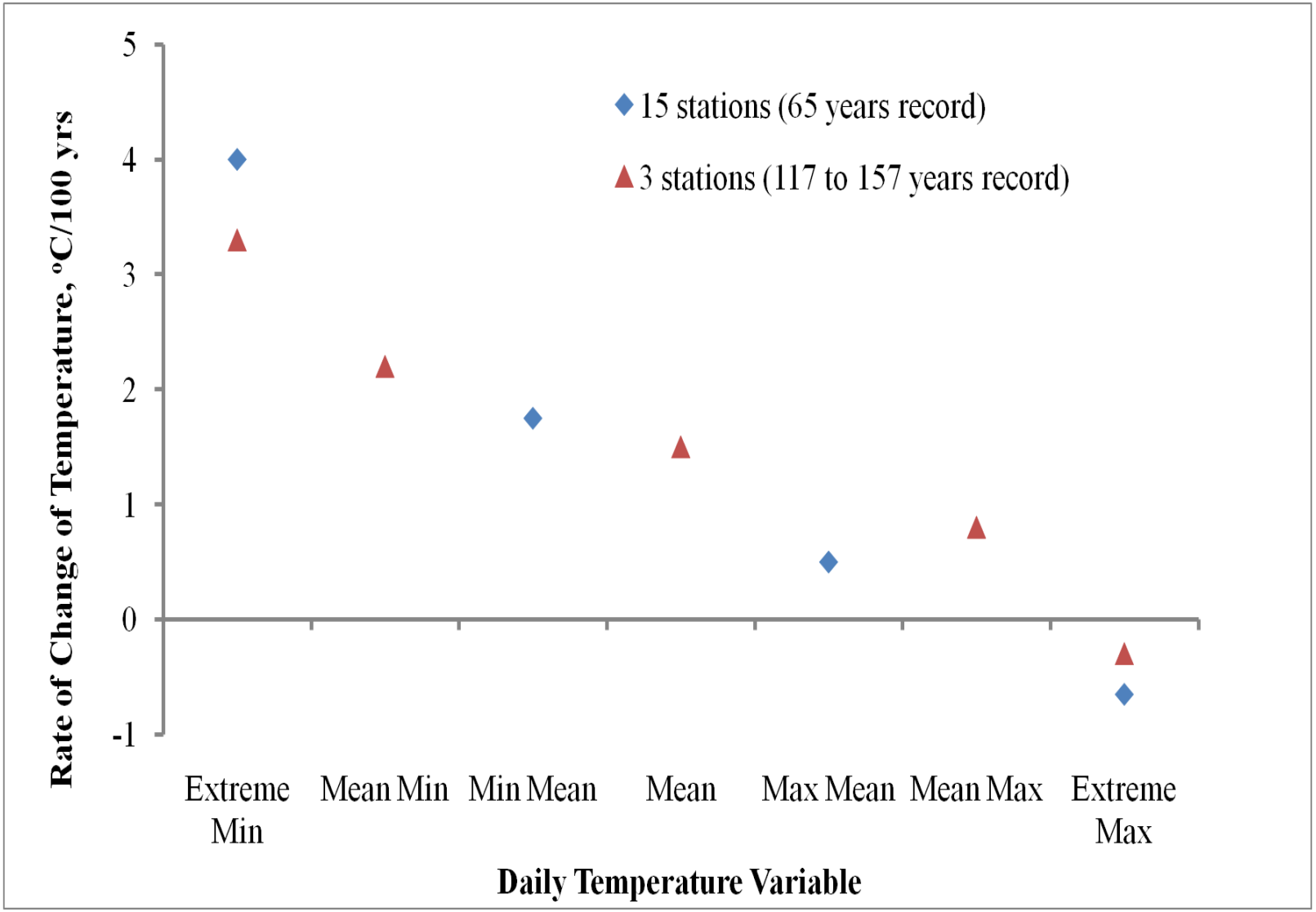
Trends in Annual Temperature

Source: Trevor Dickinson



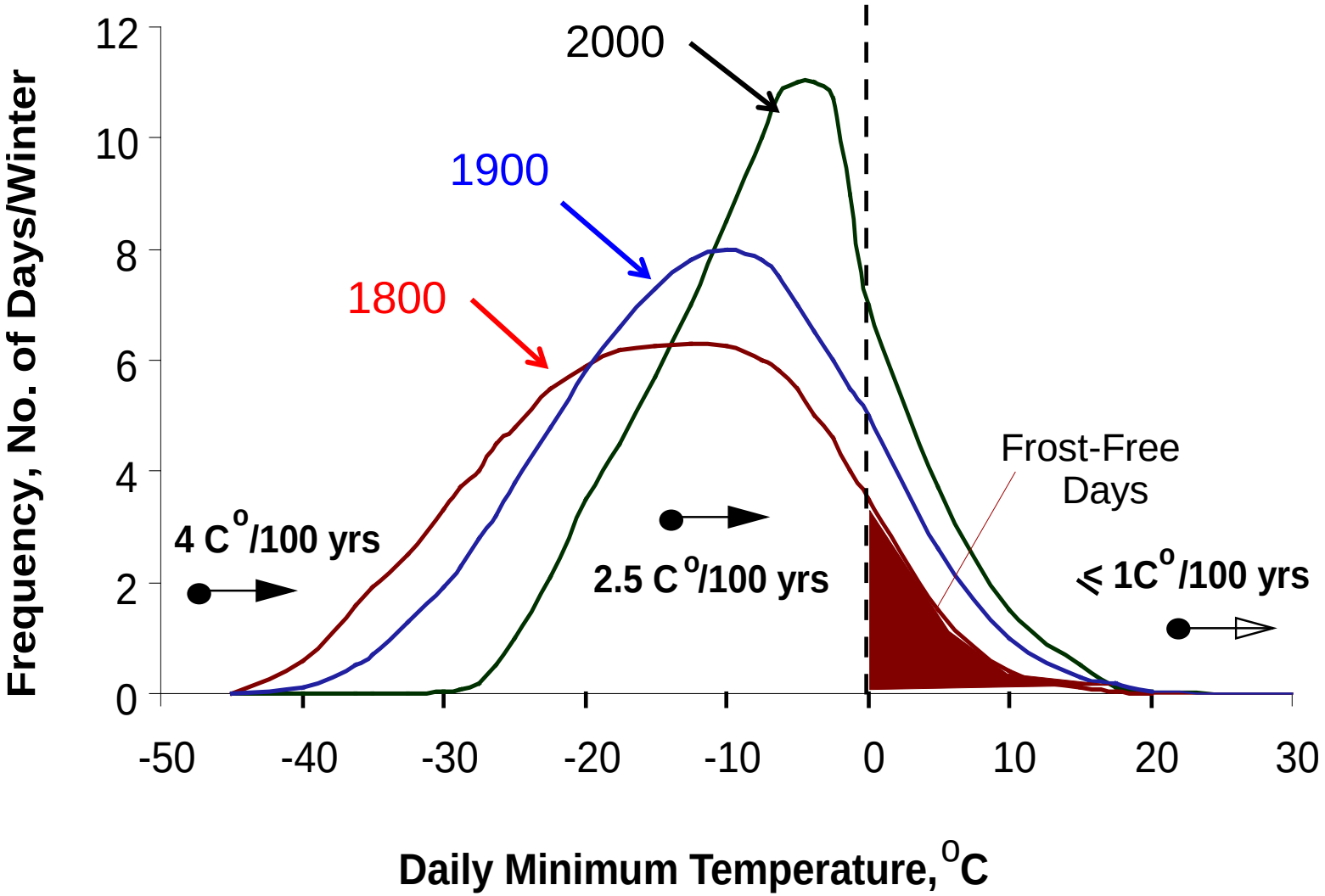
Rate of Change of Temperature

Source: Trevor Dickinson



Daily Minimum Temperature

Source: Trevor Dickinson



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Global Temperature Trend

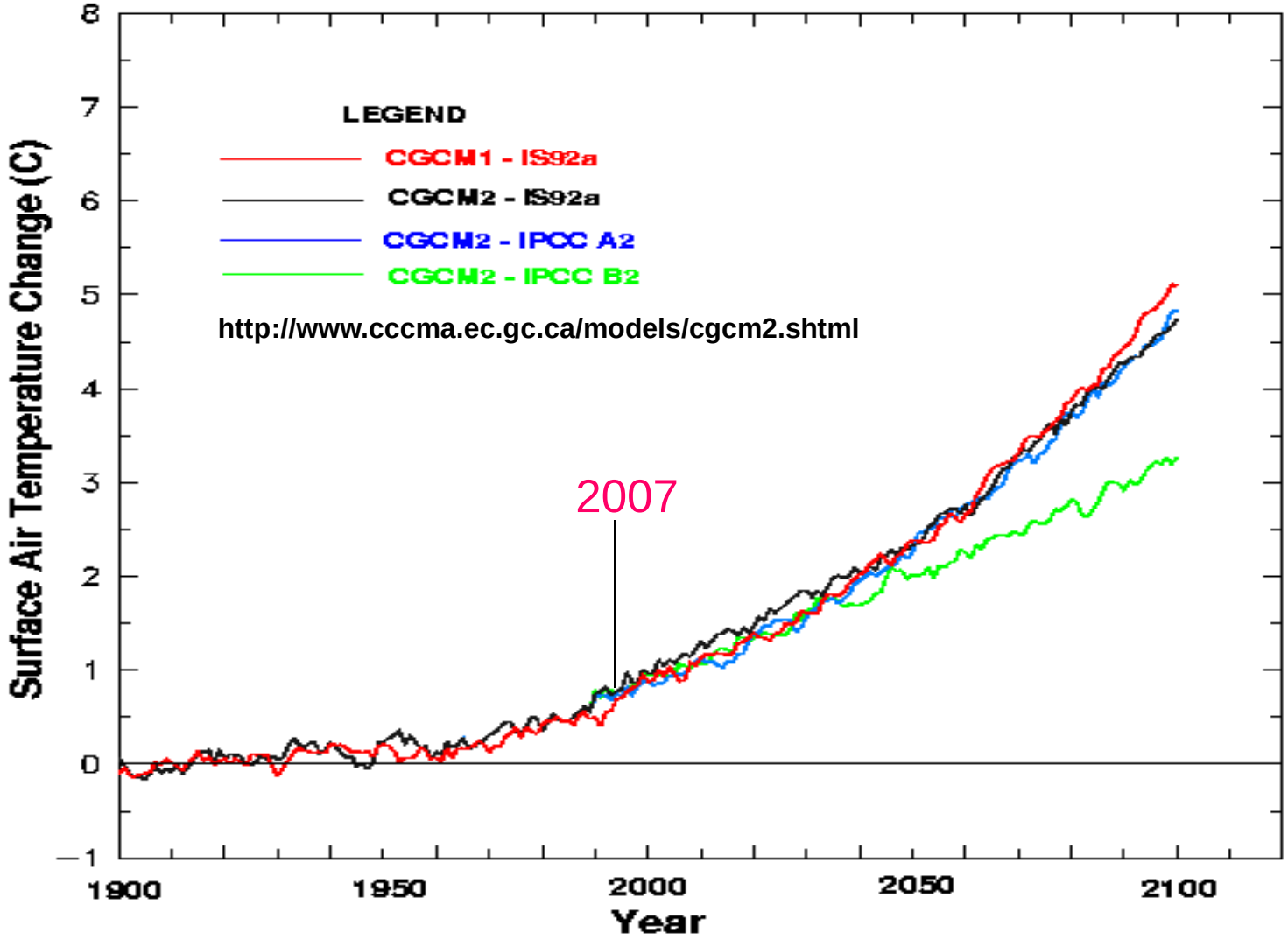
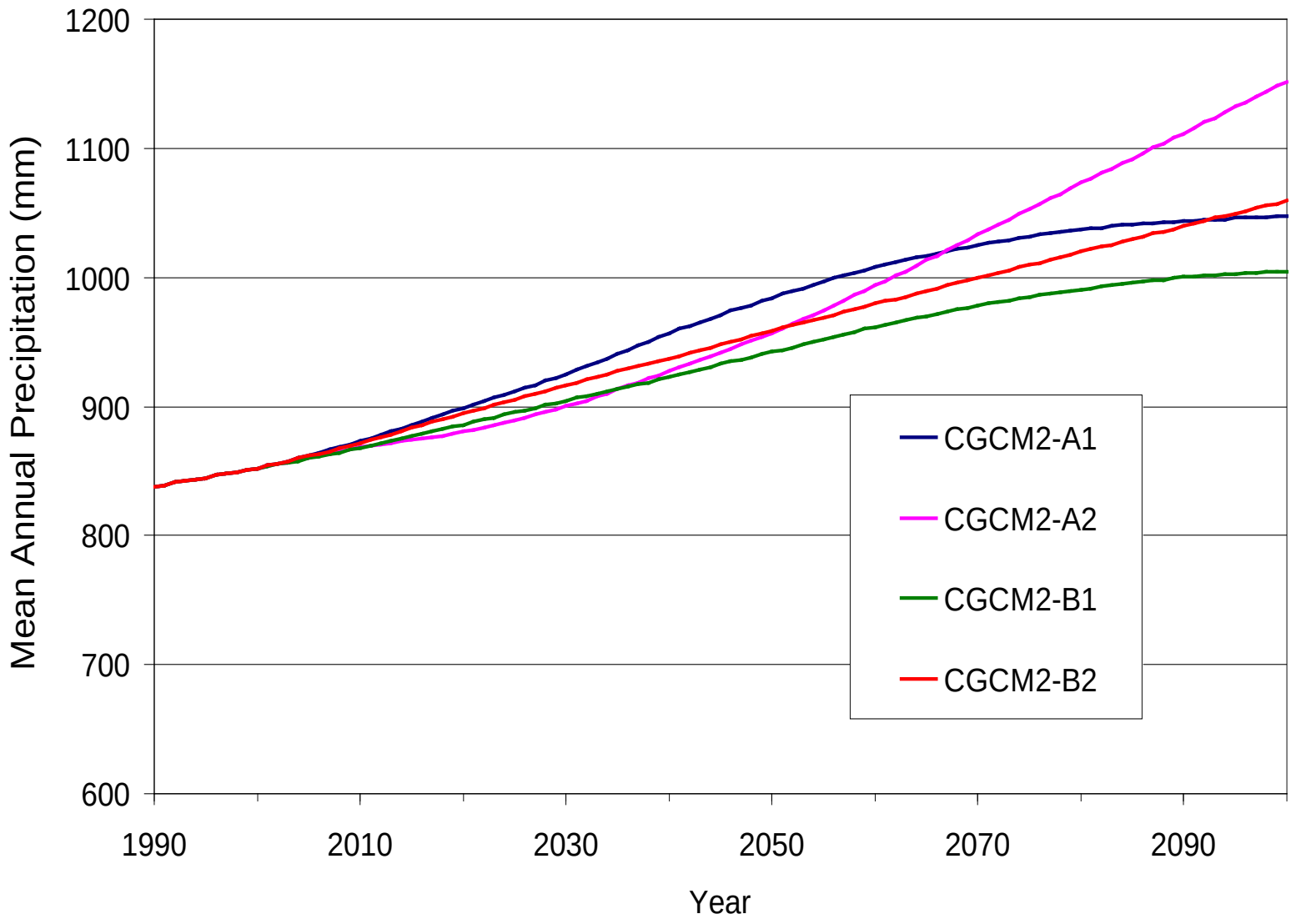


Figure 1: Global annual average surface temperature change, relative to 1900-1929 average as produced by CGCM1 and CGCM2 for various forcing scenarios.

Mean Annual Precipitation



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Historic Long-Term Daily Climate Records

	Station	Coordinates		ELEV	Year	First	Recent
Location Name	ID Code	Lat	Long	(m)	Count	Year	Year
TORONTO	6158350	43.67	-79.4	112.5	146	1860	2005
WOODSTOCK	6149625	43.14	-80.77	281.9	136	1870	2005
WELLAND	6139445	42.99	-79.26	175.3	129	1872	2005
OTTAWA CDA	6105976	45.38	-75.72	79.2	117	1889	2005
BELLEVILLE	6150689	44.15	-77.39	76.2	108	1866	2005
MORRISBURG	6105460	44.92	-75.18	81.7	93	1913	2005
MINE CENTRE	6025203	48.77	-92.62	342.9	92	1914	2005
MIDLAND WATER POLLUTION CONTROL	6115127	44.76	-79.88	180	80	1889	2005
BLOOMFIELD	6150815	43.98	-77.22	91.4	78	1896	2005
MOOSONEE UA	6075425	51.27	-80.65	10	72	1932	2005
MUSKOKA A	6115525	44.97	-79.3	281.9	72	1934	2005
TRENTON A	6158875	44.12	-77.53	86.3	71	1935	2005
MINDEN	6165195	44.93	-78.72	274.3	70	1883	2005

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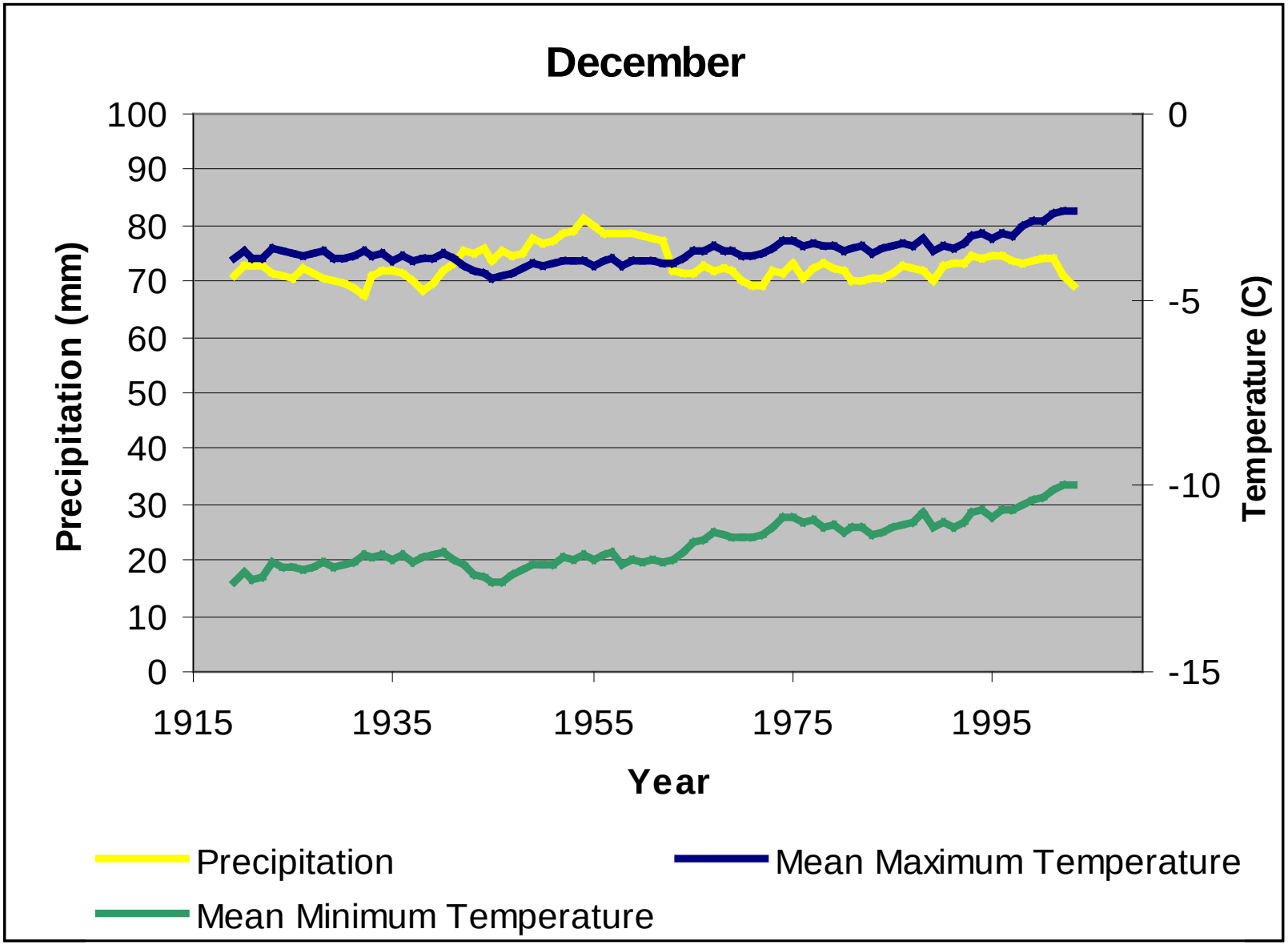
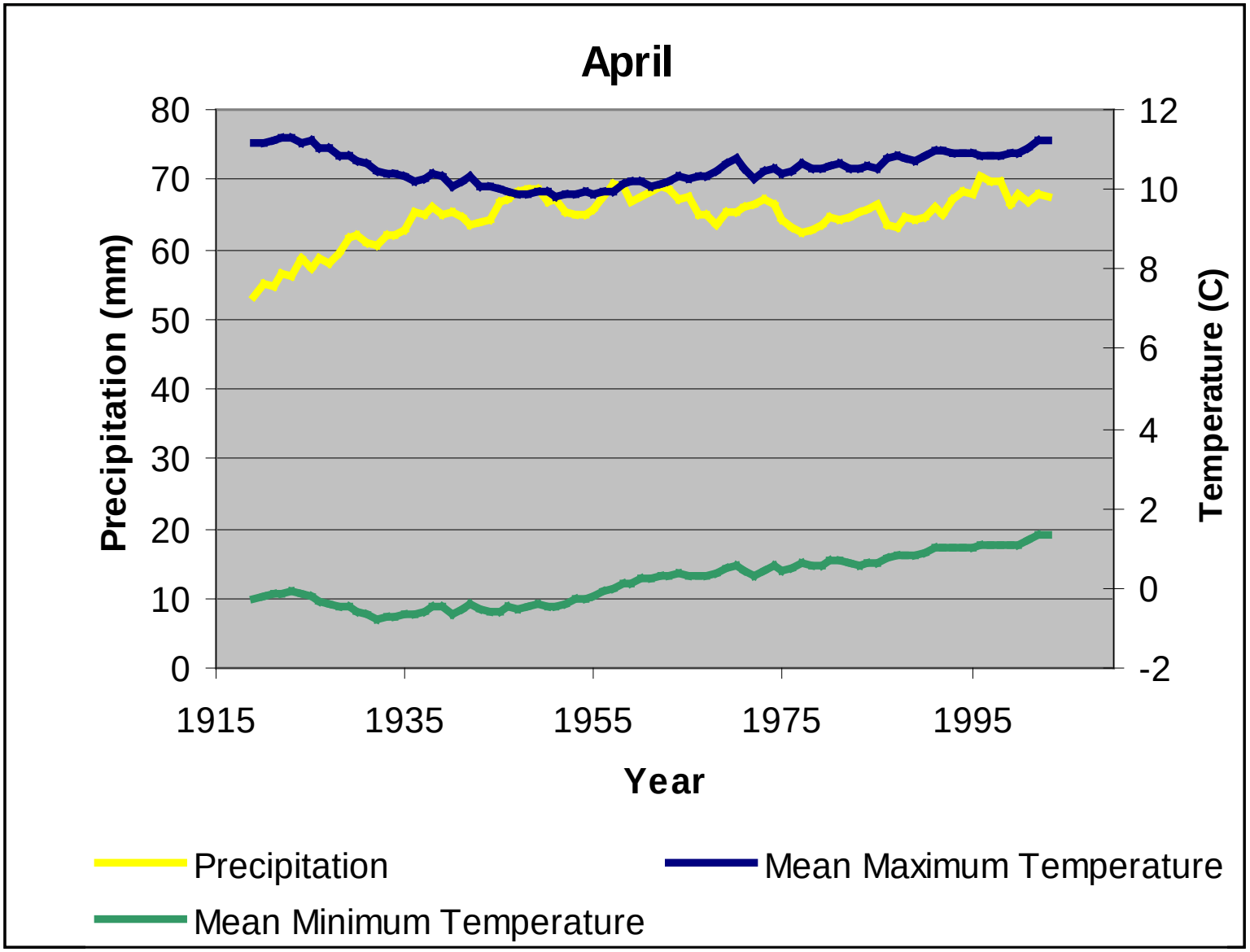
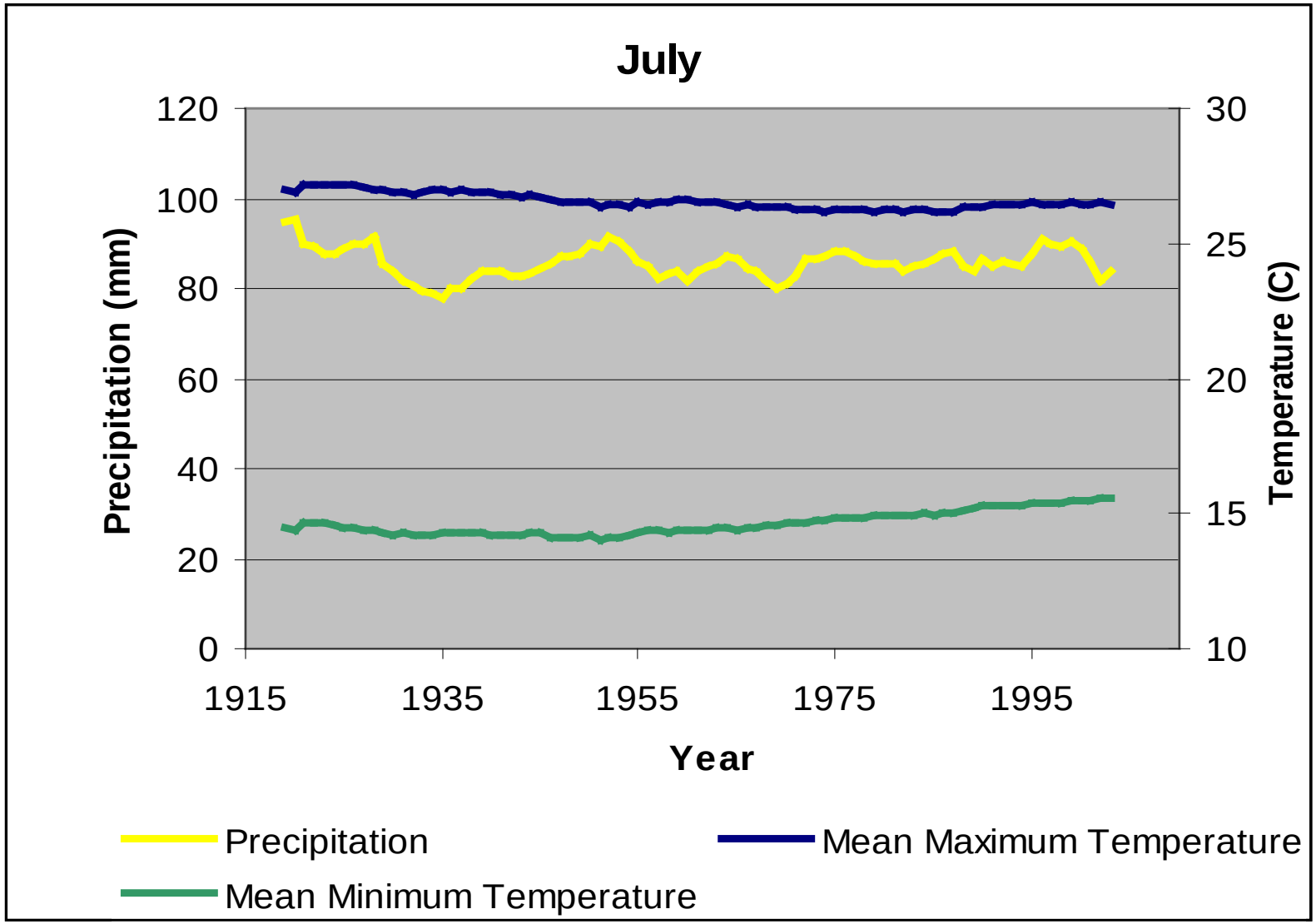
Historic Trends for December



Historic Trends for April



Historic Trends for July



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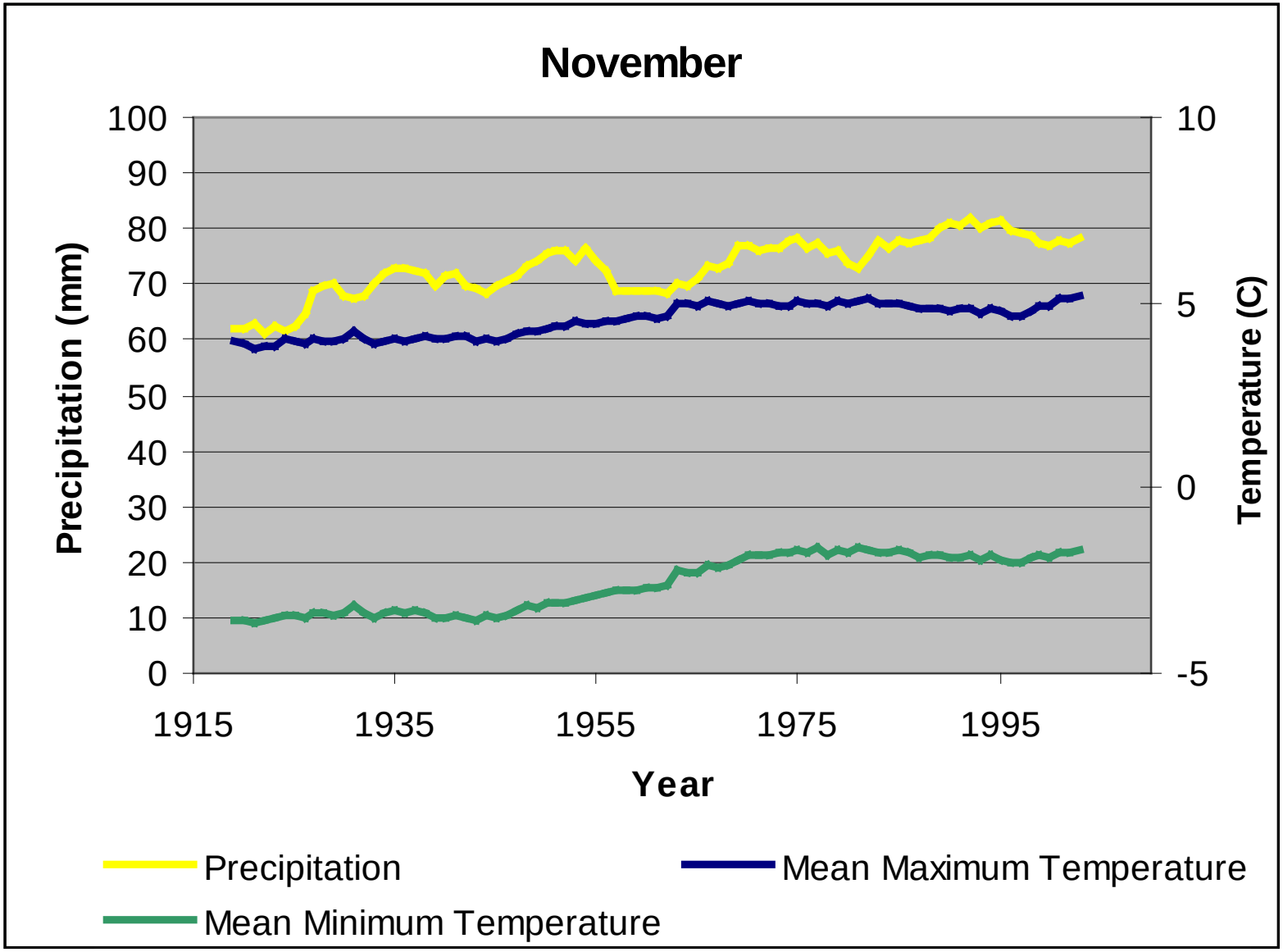
Historic Trends for November



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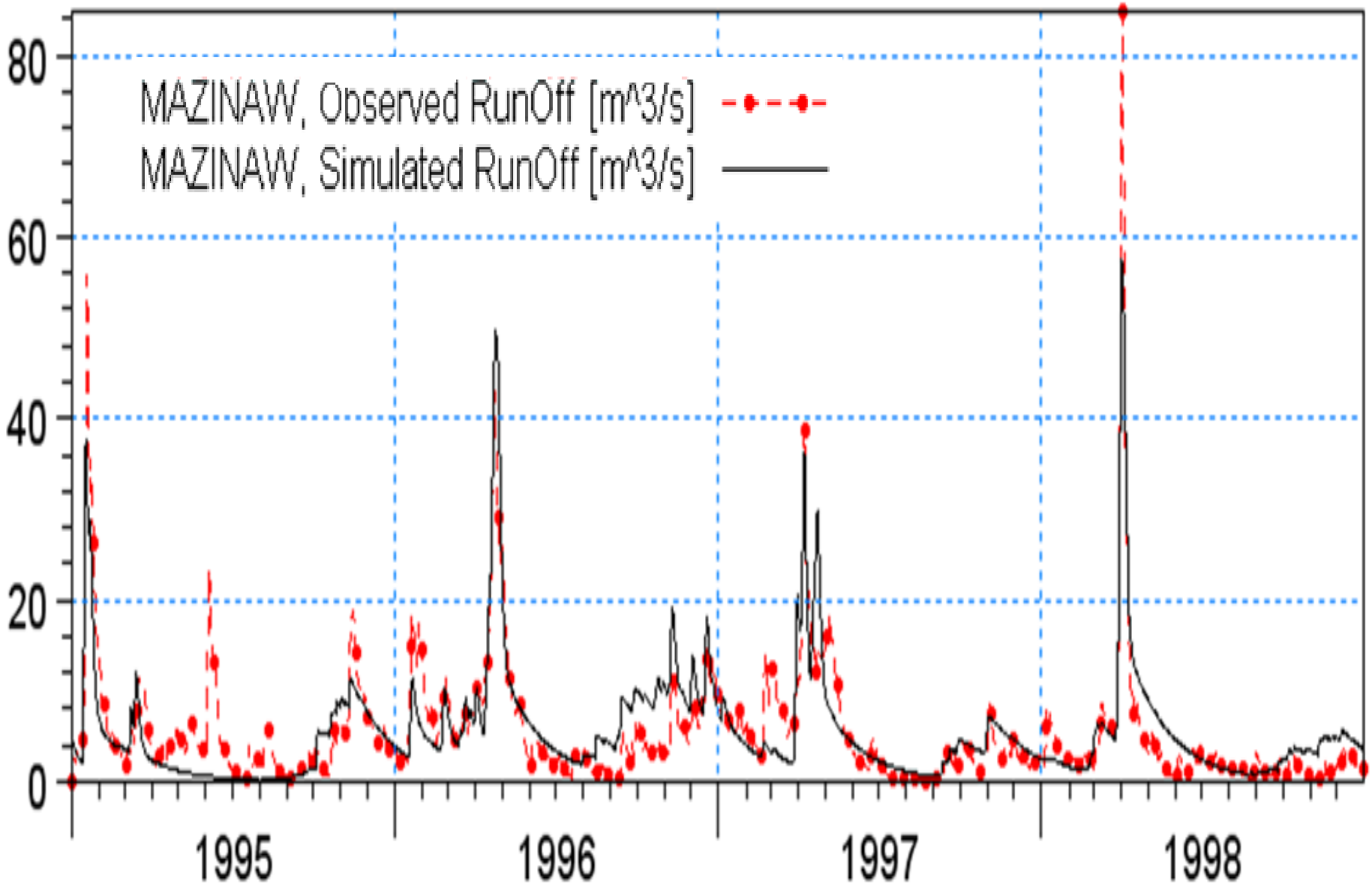
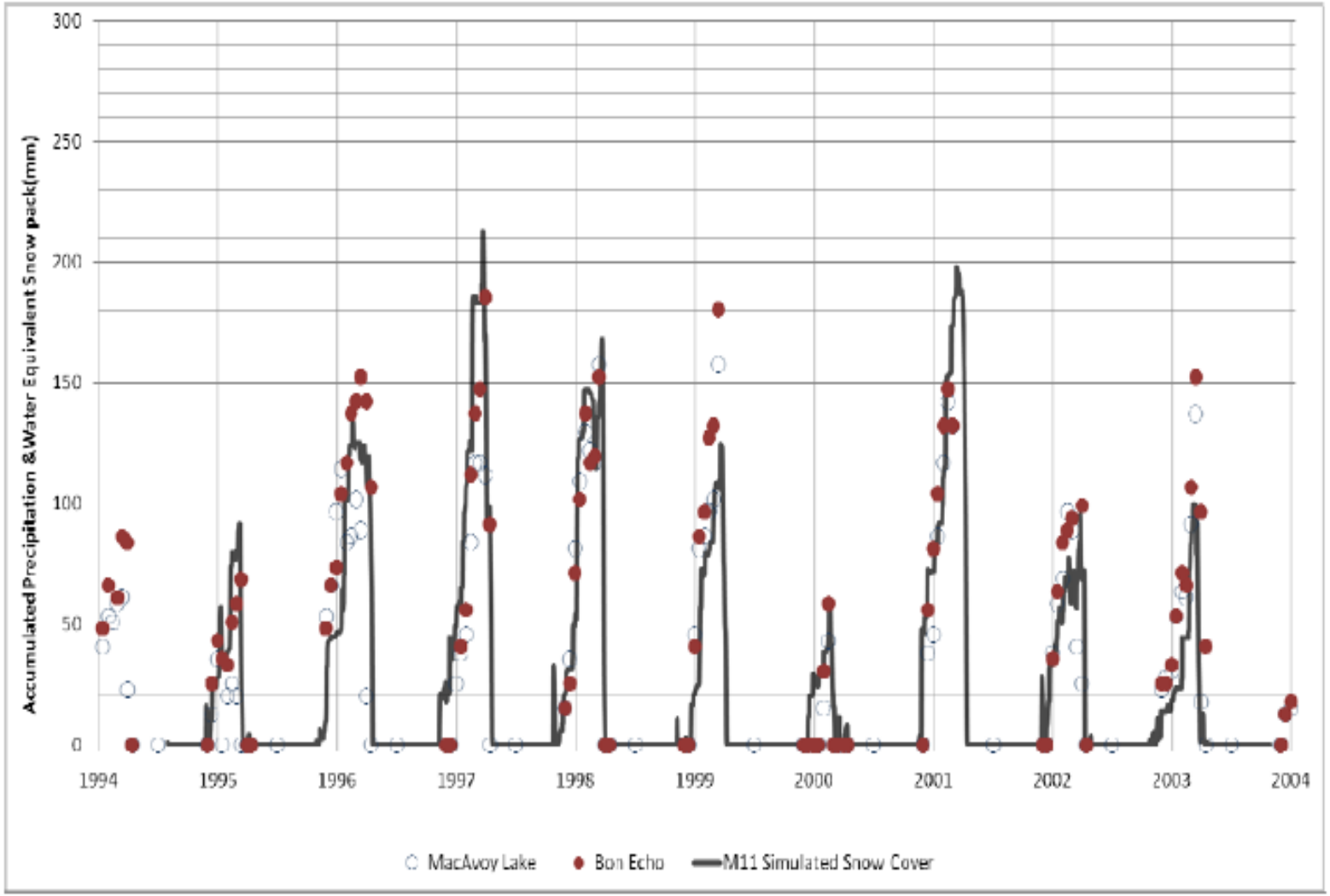
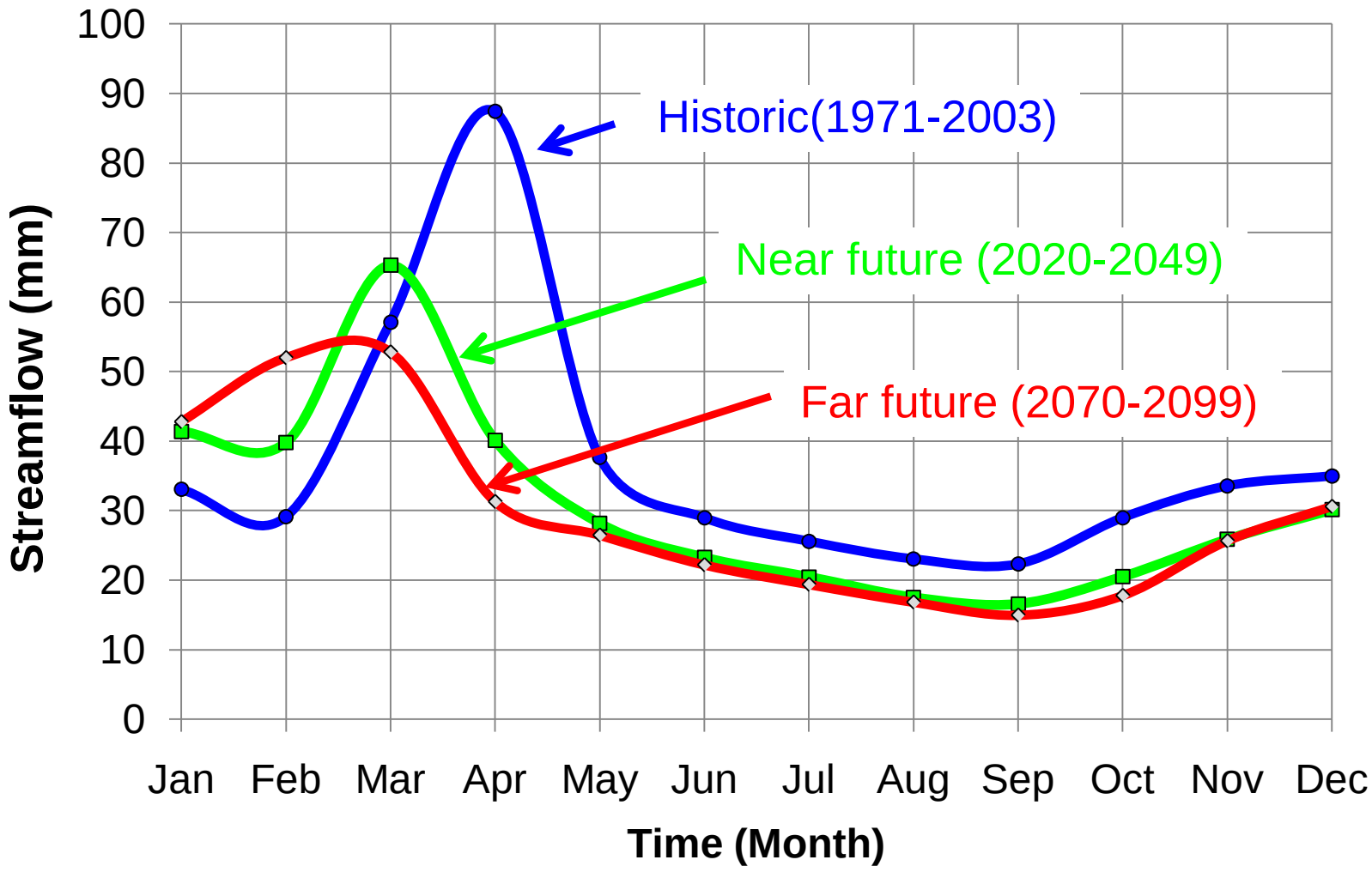
Hydrologic Model Calibration



Snow depth calibration



Mean Monthly Flow for Shabomeka

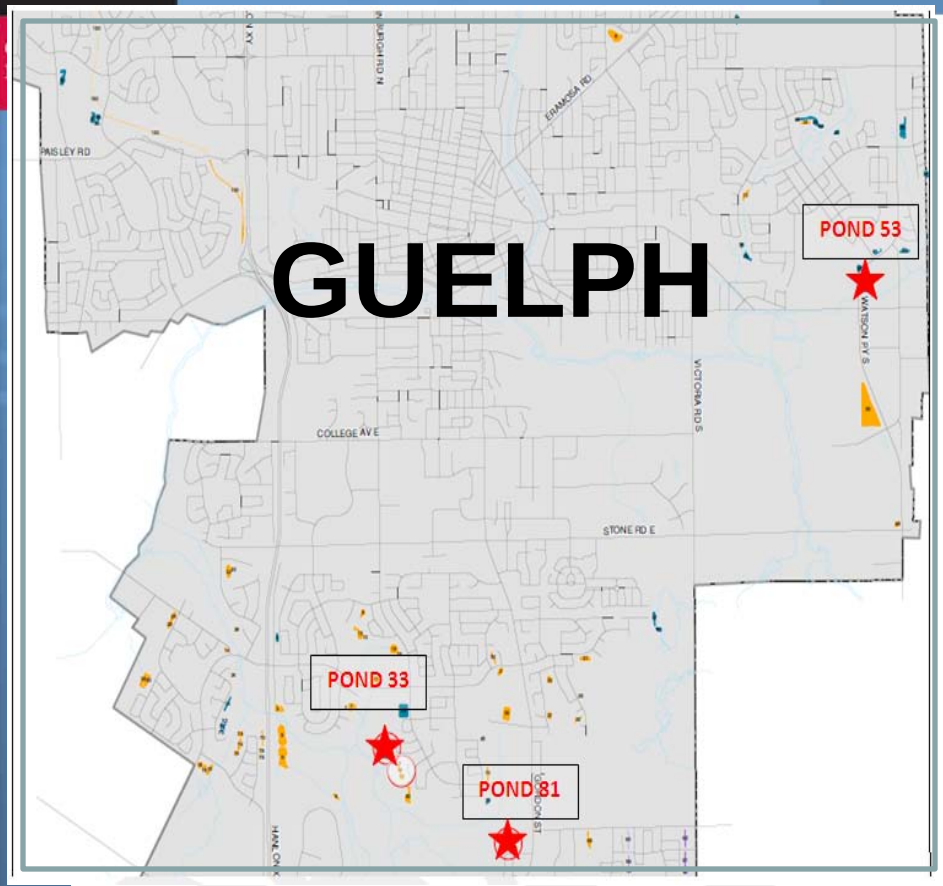


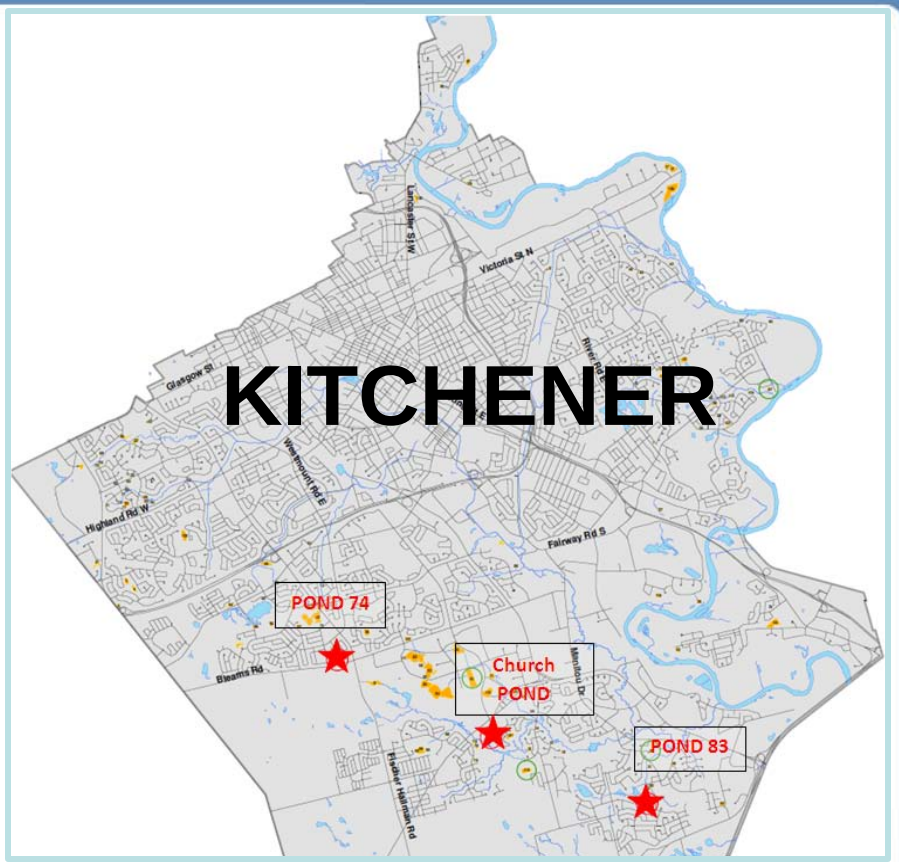

Adverse Water Quality ?

Adaptation Strategy?

- Significant increase in air temperature
- Snowfall events have turned into rainfall events
- Prolonged wet spring and fall conditions
- Increase in frequency and risk of floods
- Warmer and drier summers (higher water demand)
- Increase in frequency and severity of droughts
- Increased risk of forest fires
- Degradation of stream and Lake water-quality
- Challenges for water managers operating reservoirs

Monitoring program





Pond	City	Location
53	Guelph	York and Watson Road
33	Guelph	South creek Trail, Next to preservation park
81	Guelph	East of Carrington Dr
74	Kitchener	The northwest corner of Beams Road and Fischer – Hallman Road
83	Kitchener	Topper Swamp-West pond
Church	Kitchener	The west of Strasburg Road and south-east of Huron Road

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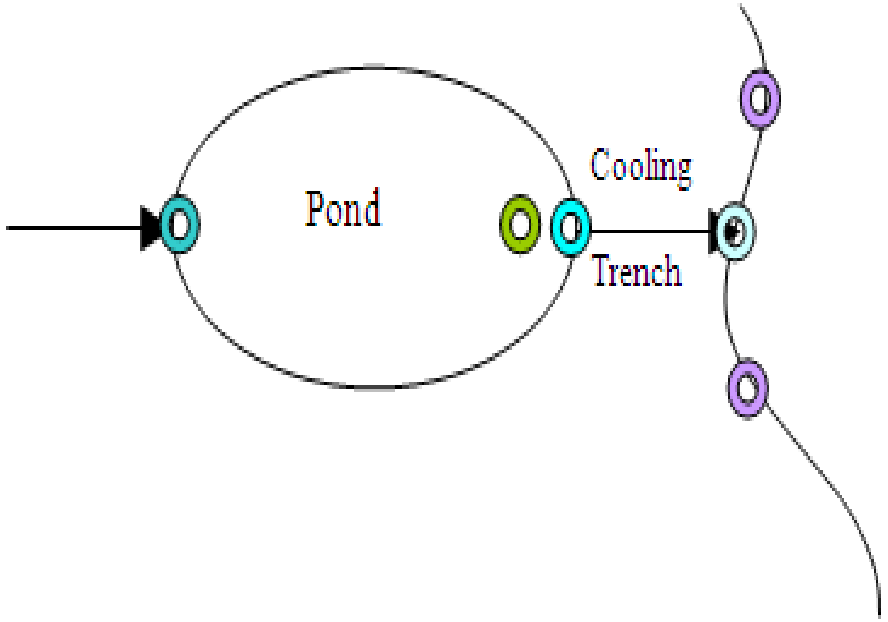
Ponds and Catchment Areas

Pond #	Catchment area (ha)	Average Depth (m)	Perm. Pool Vol. (m^3)
G53	79.0	1.5	6400
G33	19.4	1.0	4000
G81	4.9	0.6	960
K74	35.8	2.5	5400
K83	10.8	1.0	1300
KCh.	5.1	0.7	950

Temperature and Water Level Monitoring



- Pond inflow temperature and depth/flow monitor
- Pond outflow temperature and depth monitor (at bottom draw outlet)
- Pond cooling trench outlet temperature monitor
- Pond stratification temperature monitor cluster (3 monitors on a weighted line at varying depths)
- Stream temperature and depth monitors upstream and downstream of pond outfall

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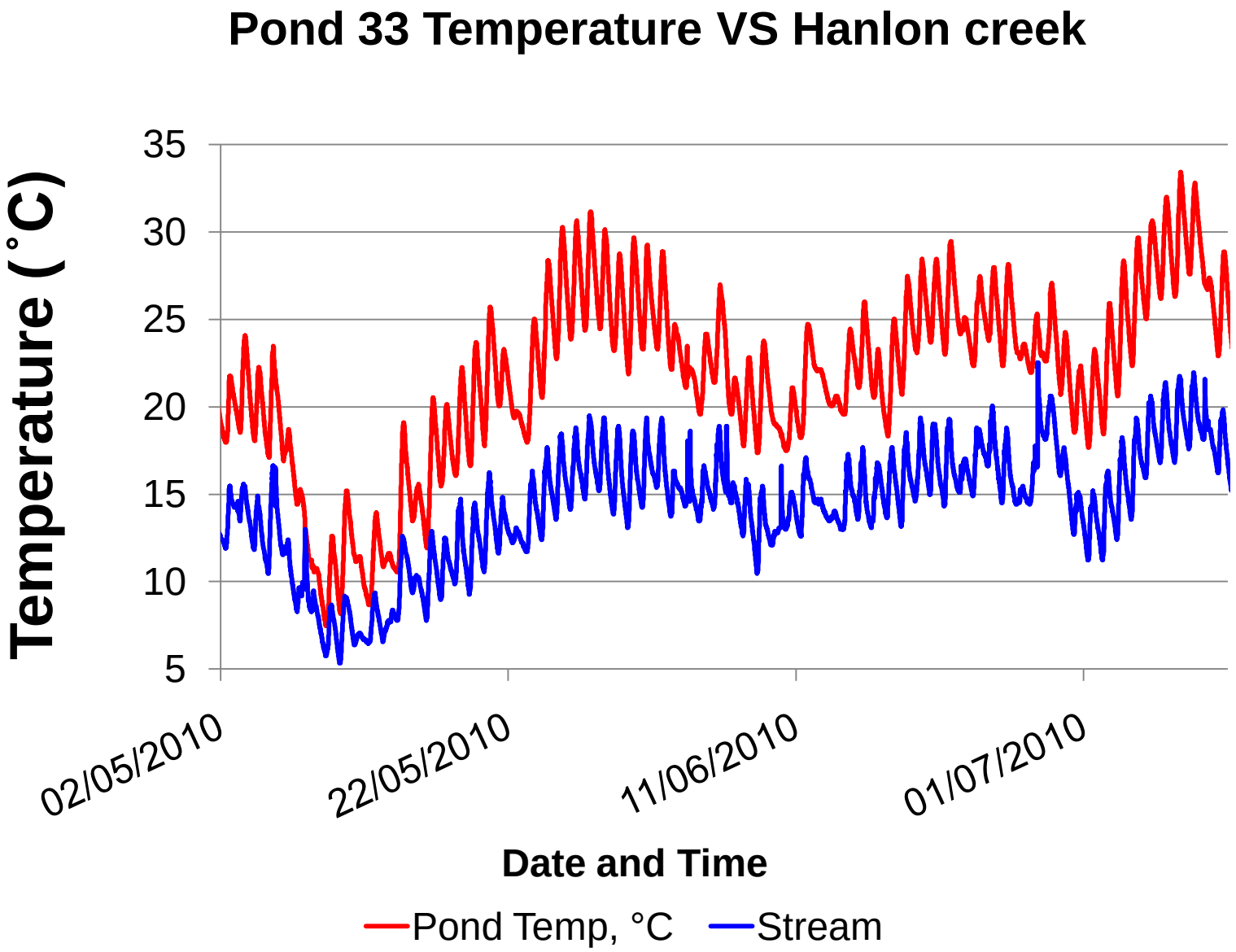
Level and Temperature Sensors

ID	Location	Type	Period	ID	Location	Type	Period
1	I 53	L & T	6JUL–30SEP	31	W74	L & T	18AUG–22OCT
2	O 53	L & T	6JUL–30SEP	32	W74, 0ft	T	25JUN–22OCT
3	W53	L & T	12AUG–30SEP	33	W74, 2ft	T	25JUN–22OCT
4	W53, 0ft	T	6JUL–30SEP	34	W74, 5ft	T	25JUN–22OCT
5	W53, 1ft	T	6JUL–30SEP	35	W74, 7ft	T	25JUN–22OCT
6	W53, 2ft	T	6JUL–30SEP	36	MH #31 pond 74	L & T	25JUN–22OCT
7	C T 53	T	25JUL–30SEP	37	MH #32 pond 74	L & T	25JUN–22OCT
8	US 53	T	6JUL–30SEP	38	CToutlet, 74	T	27JUL–22OCT
9	DS 53	T	6JUL–30SEP	39	Barometric Pr.	L & T	25JUN–22OCT
10	I 33	L & T	8JUL–18OCT	40	I, Church	L & T	4JUL–22OCT
11	O 33	L & T	8JUL–18OCT	41	O (MH), Church	L & T	4JUL–4SEP
12	W33, 0ft	T	8JUL–18OCT	42	W, Church	L & T	18AUG–4SEP
13	W33, 1ft	T	8JUL–18OCT	43	W, Church	T	4JUL–22OCT
14	W33, 2ft	T	8JUL–18OCT	44	W, Church	T	4JUL–22OCT
15	C T 33	T	8JUL–18OCT	45	I 83 , #1	L & T	9JUL–22OCT
16	CT 33	T	8JUL–18OCT	46	I 83 , #2	L & T	9JUL–22OCT
17	US 33	T	31AUG–13OCT	47	O(MH) 83	L & T	9JUL–22OCT
18	DS 33	T	20JUL–13OCT	48	W 83	L & T	18AUG–22OCT
19	I 81	L & T	5JUL–30OCT	49	W 83, 0cm	T	9AUG–22OCT
20	O81	L & T	5JUL–30OCT	50	W 83, 20cm	T	9AUG–22OCT
21	W81	L & T	20AUG–30OCT	51	W 83, 40cm	T	9AUG–22OCT
22	W81	T	5JUL–30OCT	52	Backup 74	T	25JUN–22OCT
23	W81	T	5JUL–30OCT	53	Backup 74	T	25JUN–22OCT
24	CT 81, 0 cm	T	5JUL–30OCT	54	Backup 74	T	25JUN–22OCT
25	CT 81,20 cm	T	5JUL–30OCT	55	Backup 74	T	25JUN–22OCT
26	CT 81, 40 cm	T	5JUL–30OCT	56	Backup 81	T	5JULy–30OCT
27	US 81	T	20JUL–13OCT	57	Backup 81	T	5JULy–30OCT
28	DS 81	T	20JUL–13OCT	58	Air 53	T	12AUG–30SEP
29	I 74	L & T	25JUN–22OCT	59	Air Temp.	T	30SEP–30OCT
30	O(MH) 74	L & T	25JUN–22OCT	60	Air 33	T	20AUG–16OCT

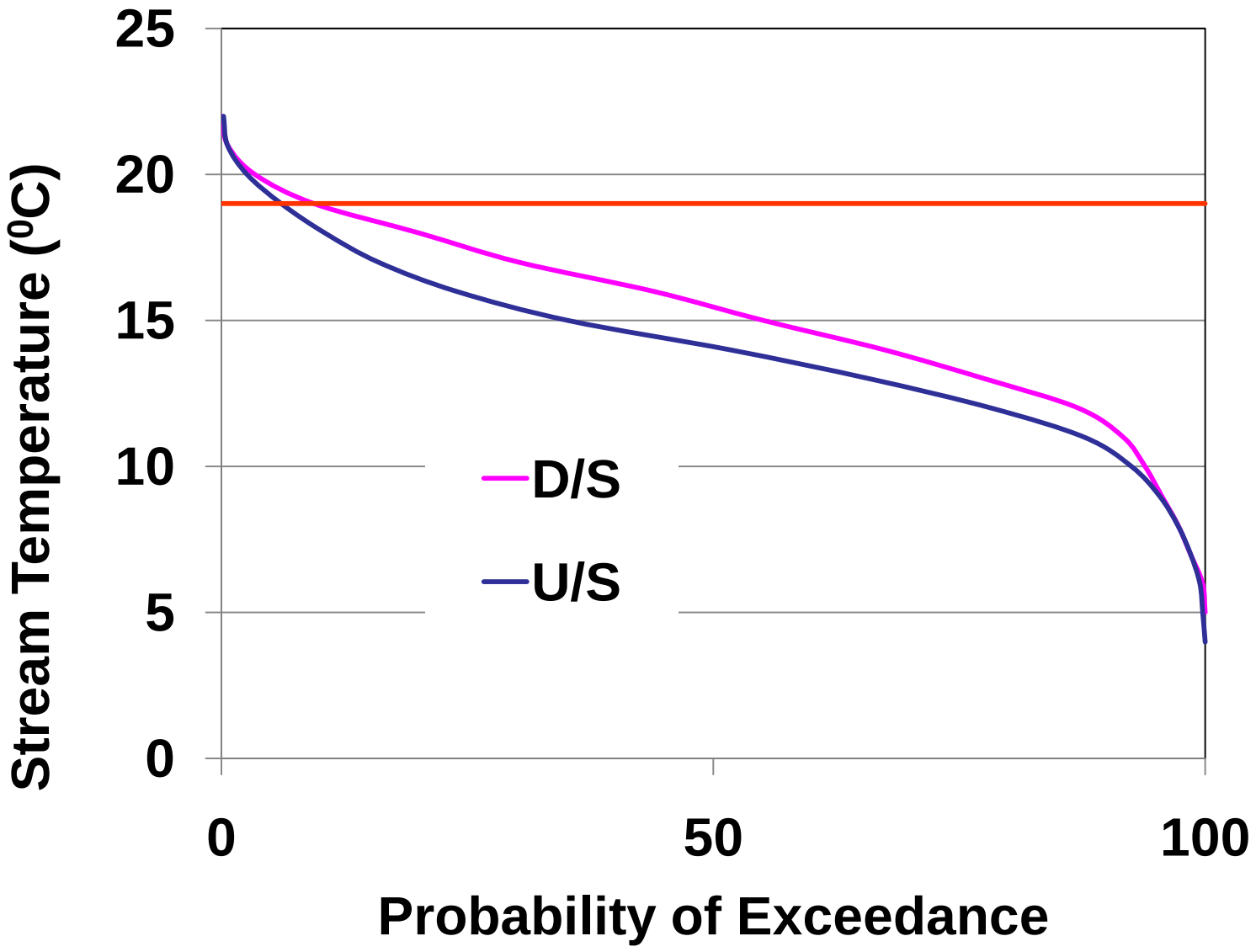
Pond 33 - Guelph

Source: Google Map

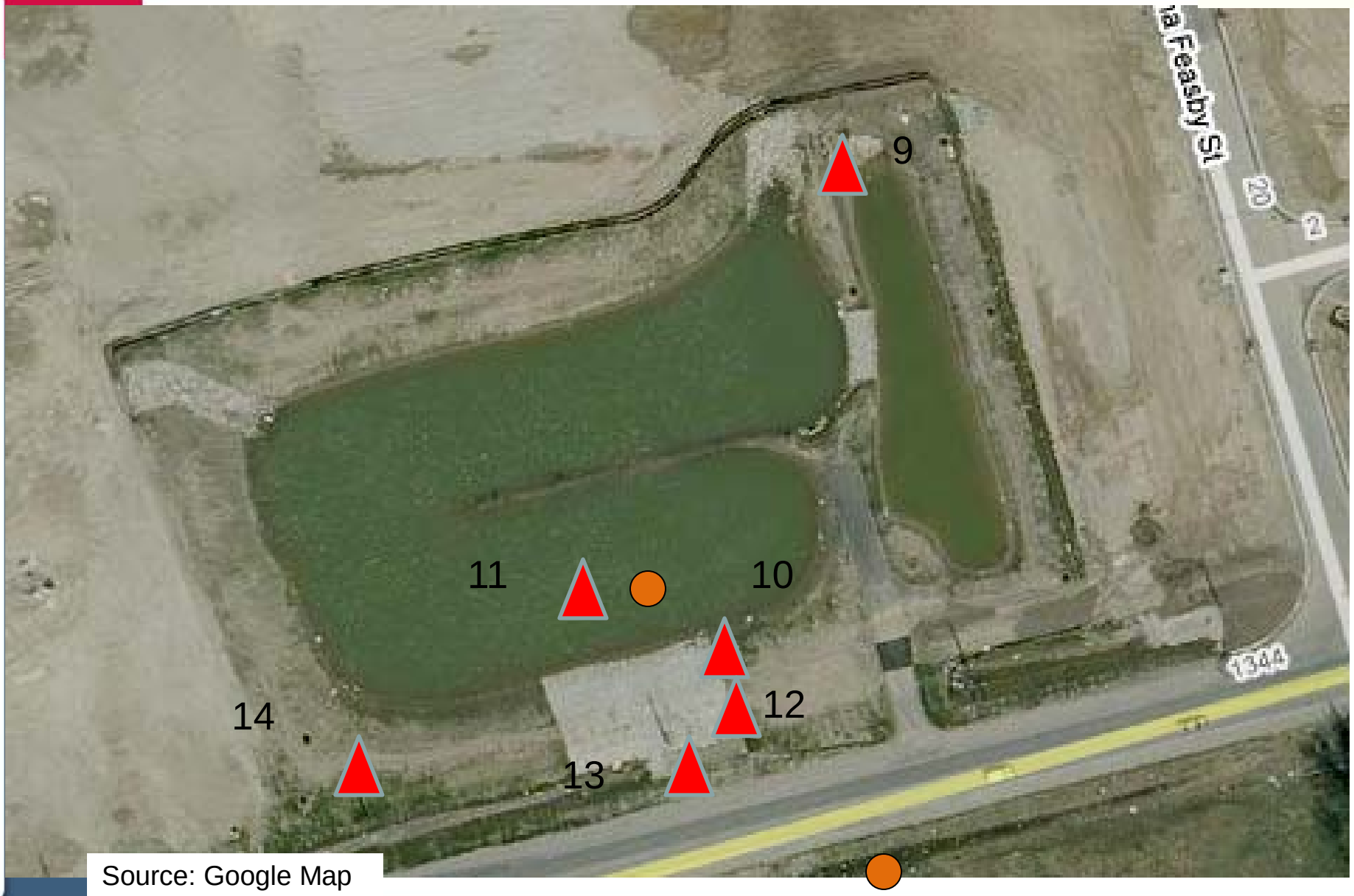
Thermal Enrichment



Hanlon Creek - Guelph



Pond 74 – Kitchener



Source: Google Map

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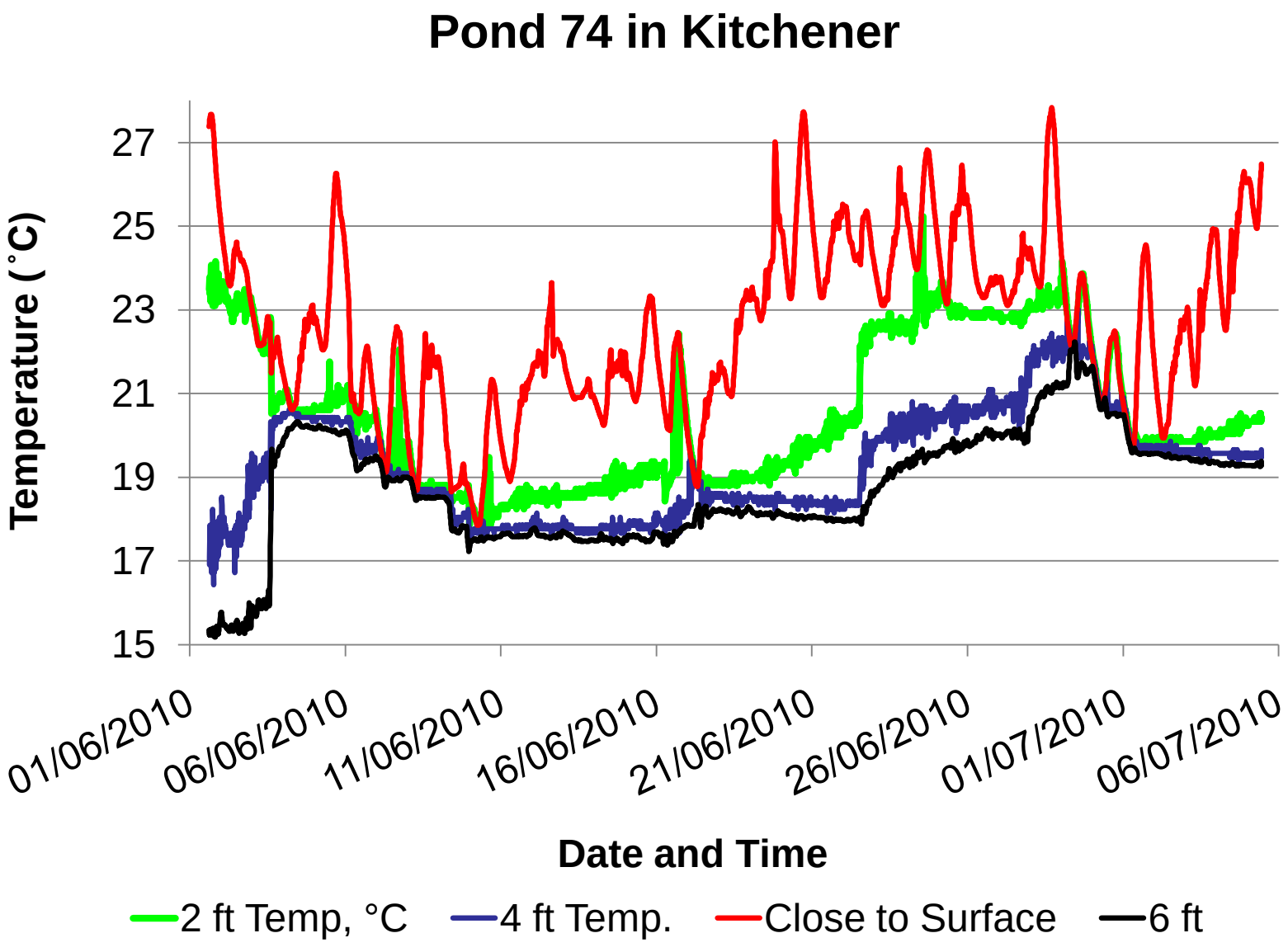
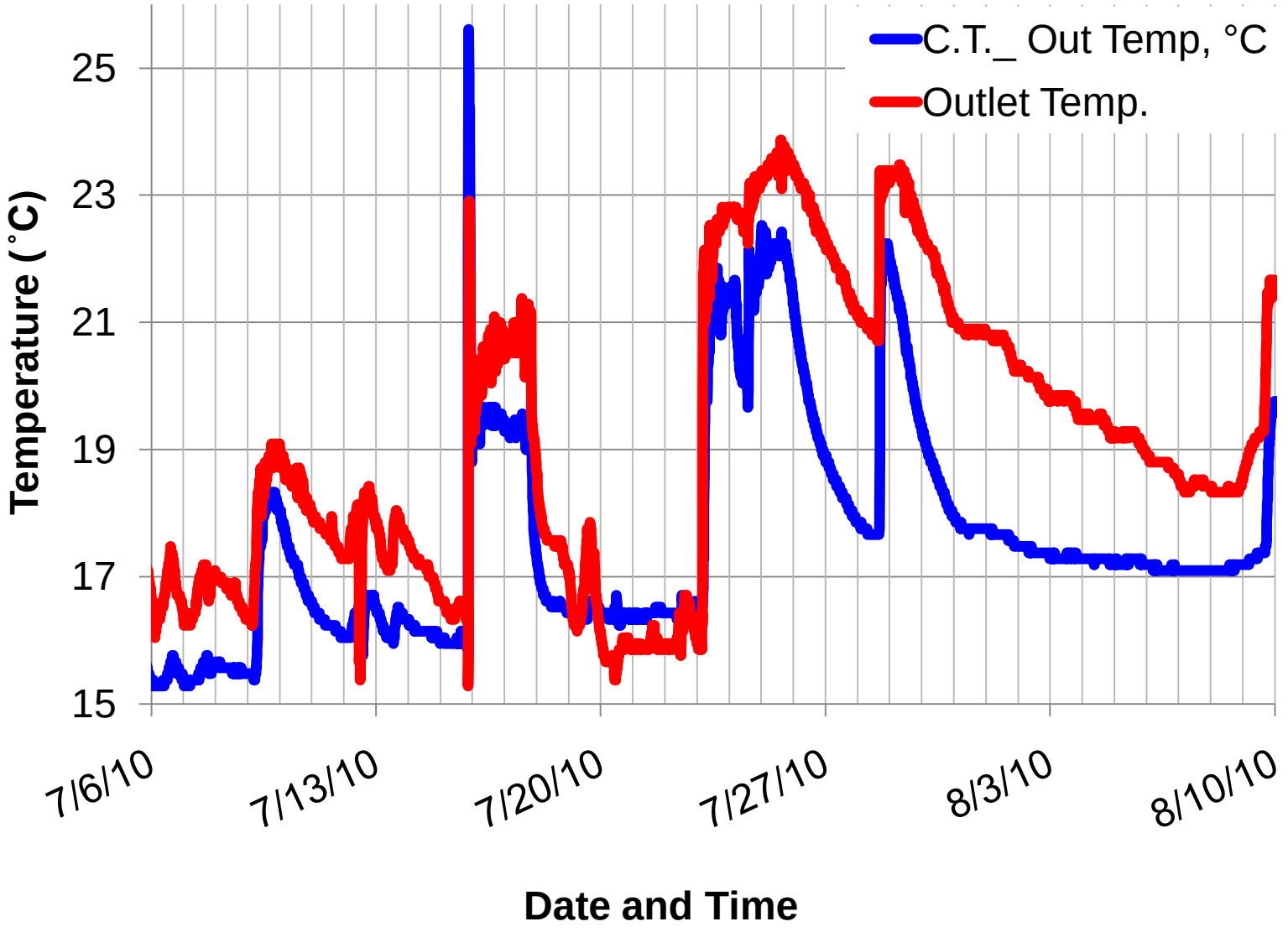
Temperature at Different Depths



Pond 74 Outlet and Cooling Trench



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